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ORGANIC SENSATION¹

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¹The investigation of which this article forms a part was first taken up in the Cornell Laboratory in the year 1905-6. A related article appeared in this *Journal* in July, 1908.

It was our original intention to limit this study to the sensations originating in the vegetative processes of the visceral and circulatory systems, exclusive of all cutaneous or kinæsthetic components. In the course of investigation, however, the impracticability of keeping up this line of division became apparent, and the discussion is frequently broadened to cover *internally or indirectly initiated* sensation in general, a category practically identical with what Sherrington has termed the 'proprio-ceptive', as over against the 'extero-ceptive', sphere of sensation. The reasons for this will be more apparent in a discussion of the subject which is to be published later.

PRELIMINARY SURVEY

The following study represents an attempt to bring a subject commonly assumed to be of physiological import only under the discipline and into relation with the data of experimental psychology. In view of the scope and novelty of the undertaking and the inherent difficulties of the subject, apology need hardly be offered for the fact that in the following pages project rather than accomplishment is presented to the reader.

To the rôle of somatic sensation in our daily consciousness various set descriptive phrases, such as the 'thrill of pleasure', the 'shock of surprise', the 'pang of dismay', the 'wave of pity', the 'shudder of disgust', bear witness. That these phrases are not merely metaphorical in significance, but have a direct physiological reference and derivation, that the 'thrill', the 'pang', the 'wave', has each its own more or less definite bodily seat, characteristic timbre, and limited emotional context is sufficiently patent to all. From the literature and speech of every day many phrases referring directly to heart or circulatory sensations may also be culled, *e. g.*, the heart 'aches', 'sinks', is 'ready to burst', the blood 'boils', 'curdles', the gorge 'rises', and the like. To this list other less highly colored yet distinctive and persistent bodily reactions, fatigue, hunger, tension, excitement, satisfaction, and many more or less shadowy modes of cœnæsthesia may be added. Of the group thus constituted it may be safely said that in some form or other, in the focus or margin of consciousness, one or another of them is always with us, even in the most intellectual of our preoccupations. That these, the most intimate, unescapable, and superficially accessible of our sensory experiences should stand to-day on the frontier as it were of the psychology of the senses is an interesting if hardly creditable phenomenon.¹ Speculation as to the significance and inner mechanism of certain of the bodily accompaniments of our mental states or emotions has indeed been rife, witness the James-Lange theory and the present discussion pro and con. But of curiosity as to the primary sense stuff of these bodily reactions, of query whether the diversity in the varying web of mood is one of 'color' or texture merely, of inquiry as to the possible existence of an extended gamut of organic as of visual sensation, of exploration of the peculiar cohesions, conformations, and behavior of such sensations in experience, there is in the litera-

¹See E. B. Titchener: The Problems of Experimental Psychology (St. Louis Congress address), this *Journal*, xvi, 1905, 212. "Of all problems in the psychology of sense that are now before us, the problem of the number, nature and laws of connection of the organic sensations appears to me to be the most pressing."

ture singularly little evidence. Yet if psychology is to be raised above the level of the merely subjective, any explanatory use of organic sensation must of necessity be preceded by some sifting of the facts and agreement as to the states in question. Here, if anywhere, are surely in order the old-fashioned, plodding methods which seek by the correlation of fixed terms with certain of the simpler, commoner, and more readily identifiable phases of consciousness to pave the way for the description and exploitation of the subtler and more significant phases within which the simpler function as partials, or prime factors.

The following research was prompted in part by a desire to bridge the gap in our knowledge of the psychology of the sensory components of experience. This motive was, however, strongly reinforced by the conviction that (all question of their specific function in the vegetative economy of the organism aside) these so-called 'by-products' of the mental life must play some considerable rôle not only as the matrix or basis of continuity of our experience, but further as conditioning in some fashion both the affective processes, and attention, action, and the interplay of ideas and meanings. Inquiry was further stimulated as the result of certain observations incidental to a laboratory investigation of the affective qualities, in which the writer, serving as observer, had occasion to note that even the simple pleasantness (or unpleasantness) occasioned by various sensory stimuli was attended in consciousness by certain more or less definite and uniform if hardly describable bodily reverberations or feelings. In view of the difficulties in the way of unequivocal correlation of affective qualities with objectively demonstrable organic changes,¹ the possibility of correlation with *felt* organic changes (such as the bodily set or mood of acceptance or rejection) is not to be let slip unchallenged. Without prejudice to the question whether or not the organic sensations form the indispensable basis and vehicle of affective experience, as d'Allonnes would have us believe, the demonstration of certain constant correlations between affection and bodily sensation would at least afford a tangible basis for the handling of affective experiences, for their release from the disconcertingly detached and disenfranchised position which they now hold in psychology.

However this may be, it is not unreasonable to surmise that the shirking of the analysis of the bulky if nebulous residue of our marginal consciousness constituted by organic sensation

¹ See, *e. g.*, R. Lagerborg's résumé of the discussion as to the symptomatic or causal relation of organic changes and feeling, in *Das Gefühlsproblem*, 1905, 42-68.

plays into the hands of an uncritical use of the 'subconscious' in explanation, and of a more or less reckless speculation as to the number and traits of the affective elements, the ultimate constitution of mind, and the functions and attitudes of the empirical (and non-empirical) ego. In view of the present unsettled state of the science, and the growing demand that psychological treatment should render itself more adequate to concrete reality, scientific economy forbids the leaving at loose ends of so large a body of conscious fact. In the attempt to establish a descriptive basis for the psychological treatment of functions and attitudes this study must inevitably contribute by bringing into the light of day many supposedly intangible and shadowy modes of experience.¹

Again, in view of the more or less prevalent lack of recognition of any simple affective consciousness other than pleasantness or unpleasantness attaching to our ordinary perceptual experiences, and the consequent reproach of over-intellectualism, the possibility that the organic coloring of conscious events may serve not only to enrich the affective consciousness constituted by the above mentioned elements, but may itself represent an independent feeling moment fairly on a par with pleasantness and unpleasantness, deserves examination. Whether or not this speculation prove profitable, introspective examination of bodily sensation under experimental conditions should be employed to establish the present debatable boundary line between organic sensations or complexes and unitary affective processes, pleasantness, and unpleasantness, or tension relaxation, quiescence, and the like, in the systems of Ladd, Wundt, and Royce.

Lastly, whatever may be the relation which subsists between feeling and organic sensation, in the opinion of the writer discussion of the James-Lange theory, and experimentation with animals and abnormal subjects in support and in disproof of it, are in a sense both premature and futile so long as the method of introspection has not been stretched to the uttermost and the possible organic contributions to emotion, and their behavior in simpler and more complex contexts critically examined.

¹With an organic terminology at our command we shall be able to do fuller justice to the reactive as well as the presentative aspects of perception and thought. It is indeed the hope of the writer, as doubtless of many others, that a study of the organic margin or lower stratum of everyday consciousness will not only ultimately contribute to the elucidation of such refractory psychoses as the judgment of certainty, of likeness, the feeling of reality, of contrast, of recognition, but may even furnish a basis of distinction for peripherally and centrally excited elements, for recollection and imagination, as well as for many of the so-called 'feelings of relation'.

PRIMARY PROBLEMS OF ORGANIC SENSATION

Certain fundamental questions as to the nature and conditions of appearance of organic sensation in contradistinction to recognized sensory qualities loom large at the very outset of our undertaking. Is, for instance, the customary dichotomy of sensation into external and internal psychologically valid? Does it have its roots in a fundamental disparity between the underlying psychophysical conditions or is it an epistemological distinction merely? Does it have an ultimate justification if not in elemental qualitative differences, at least in the diverse structural or textural patterns and cohesions to which the two classes of sensation are liable, or in the extent to which they are amenable to analysis and reproduction? The sources to which we may apply for aid in the solution of these problems are various. Casual references to organic sensation in literature in general; in monographs dealing with the problem of feeling in especial; the relevant facts of histology, physiology, and pathology; and, lastly, direct experimentation and introspection, must all be drawn upon to contribute what light they may to the subject. Preliminary to more detailed discussion, the general trend of opinion of psychologists and physiologists on three or four elementary phases of the problems involved will be briefly sketched. The neurological, physiological, and pathological evidence bearing on these same problems will then be more minutely examined.

1. *Possibility of observation in the sphere of organic sensation.* In explanation of the dearth of systematic observations in this field many difficulties have been cited; the inaccessibility alike to experimentation and attention of the sensations concerned, their alternately feeble and violent character, high affective tone, unanalyzability, and vague sensory coloring.¹ With re-

¹The problem is somewhat obscured by the custom deriving from Weber, Wundt, and Goldscheider of lumping organic or visceral sensation with the *Gemeinempfindungen* ('common sensation'), a class which by definition consists in whatever residue of sense material proves resistant to elaboration, analysis, and localization. The significance attributed to this classification varies considerably in the different writers, and may be quoted here in view of its bearing on their several attitudes toward organic sensation proper. The term or its equivalent is used in turn to cover sensation derivable from any portion of the body or any nerve, sensation referred to the body (as a whole), or totally unreferred, subjective. In the usage of J. Mueller the significance of the adjective 'common' is anatomical or topographical merely: common sensation (*Gemeinempfindungen*) includes the pain-pressure-temperature equipment common in his belief to the exterior and interior of the body alike. Weber, using the term *Gemeingefühl* or *Gemeingefühlsempfindung*, gives it an epistemological turn: common sensation is unexternalized sensation, the raw sense material in the formal elaboration of which and the application of spatial, in-

gard to the impracticability of experimentation, a word only is necessary. This difficulty first finds expression with Weber, who in listing the reasons why our inner sensations are customarily outside the range of apperception, gives prominence to the fact that our inner organs possess no *Ortsinn*, and are withdrawn from the possibility of the local application to their surfaces of moving or changing stimuli, hence can never take their place in the world of outwardly referred, spatially determined perceptions.¹ For this formulation of the difficulty the Kantian principle adopted by Weber that only the *spatially* determined and outwardly projected² attains to any degree of

tensive, or qualitative categories to which perception is balked, either by the violence of the sensation itself or the conditions of its origin (internal stimulation). This rubric, which includes tickle, itch, organic sensation and pain, is stretched to cover muscle sensation also, but obviously not without violence to the original meaning. Practically the same subdivision is set up by Wundt on the basis of the internal nature of the stimulus (functional changes, central irradiation, etc.) as a condition unfavorable to projection. Wundt, however, sees the impossibility of retaining kinæsthetic sensations in the category, though still including pain, which certainly may appear in as objective a light as strain. Goldscheider, using the term *Gemeingefühl*, shows a tendency to apply it to organic and external sensation only in so far as these are actually unanalyzed and unprojected, *i. e.*, felt rather than perceived. Thus a faint tactual impression may consist either in a touch perception, a tickle feeling, or both, according to the conditions under which it appears. Kröner, on the other hand, insists upon the limitation of the term *Gemeingefühl* to its strict logical signification, *i. e.*, a sense consciousness absolutely unanalyzable (owing to the central or general nature of the stimulus), and referred to the body as a whole. Hunger, thirst, drowsiness, nausea, general bodily comfort or discomfort, and various other organic states, belong under this heading. Lagerborg makes a somewhat similar use of the category of *Gefühl* as representing undifferentiated or fused organic sensation and inclusive of unitary bodily states (Lust, Unlust and the like), and exclusive of organic sensations in so far as these are localized or analyzed.

¹E. H. Weber: *Tastsinn und Gemeingefühl*, in R. Wagner's *Handwörterbuch d. Physiologie*, 489-91.

²See Weber's peculiar distinction between *Empfindung* and *Vorstellung der Empfindung*, *op. cit.*, 485-7, and 489-91, in which he maintains that only that which changes, or, more precisely, which can be made to pass through a minute and varied series of changes through the introduction of movements, is susceptible of separation from the self, of spatial reference and perceptive clearness. The subjective, on the other hand, represents not so much the *self-referred* as that portion of the raw material of sense which because it is relatively constant and unchanging remains unreferred, unlocalized, hence chaotic, vague, unclear. For a somewhat similar emphasis on the correlation of clearness and minute spatial delimitation and reference, see E. Meumann: *Zur Frage der Sensibilität der inneren Organe*, *Archiv für die gesamte Psychologie*, IX, 1907, 57, 58. Where Weber neglected the possibility of differentiation and analysis through any other means than movement and localization, Meumann overestimates

apperceptive clearness is obviously responsible. At any rate, it is obvious that the difficulty cited applies mainly to our knowledge of the general contours and positions of our internal organs rather than to the observation of the varieties of sensation to which, functioning as wholes, the lungs, heart, diaphragm, stomach or internal circulatory system may give rise.

This experimental difficulty finds a later version in the statement of Külpe¹ that the customary experimental appliances for the facilitation of the isolation of constituents are here useless. This objection likewise rests on a false parallel between external and internal conditions. In the first place there is no reason for assuming that even if appropriate methods were applicable any great differentiation of sensation in different portions of the same organ would be discovered. In the second place, psychology is interested less in the sensory mapping of the viscera than in the peculiarities of organic sensations themselves, and the impossibility of detailed surface exploration by no means precludes the isolation of individual qualities or masses of sensation due to the functioning of an organ or tissue as a whole, through indirect stimulation by drugs, chemicals, or by taking account of various known correlations of external stimuli and internal *Mitempfindungen*.

There are, however, according to many writers, more serious obstacles in the way of the analysis and localization of internal sensation. Certain inherent peculiarities in the normal anatomical and physiological conditions of production of organic sensation manifested on the conscious side in its intrinsic vagueness, diffuseness, feebleness and violence, effectually debar it from the realm of clear perception. Among the unfavorable conditions specifically mentioned we find the scanty sensory innervation of the viscera², the central or diffuse and

the clarifying value of the spatial reference and definition contributed by the visual image. Both positions, in our opinion, exaggerate the importance of one among several possible contributory factors in attentional clearness.

¹O. Külpe: *Outlines of Psychology*, 140.

²According to Müller, who perhaps set the tradition on this point, the feebleness and vagueness of internal sensation is the necessary correlate of the fact that the interior of the body is innervated chiefly by the sympathetic system, the primary office of which is the mediation of reflexes, not of sensation, and the ganglia of which were in Müller's day believed by some actually to function as the suppressors of sensation. Müller himself seems to have assumed, as Mackenzie, Head and others have more recently maintained, that the sympathetic possesses in its own right little or no entrée to the sensorium, depending, in cases of high intensity, on a forced passage over the fibres of the cerebro-spinal system correlated with pain. See J. Müller: *Elements of Physiology* (tr. by Baly, 1837), Vol. I, 723, 795-9.

general character of the adequate stimulus, and the possession of a peculiar secondary conduction path functioning in the case of pain.

Among those maintaining the essentially feeble and liminal or subconscious character of the internal sensory processes in their non-painful phases are Lotze,¹ Höffding,² Wundt,³ and Ladd.⁴ According to all, the affective tone correlated with the consciousness of bodily state (cœnaesthesia) is far more prominent than the semi-chaotic mass of sensation to which it is attached, and which may even be totally submerged. This state of affairs is indeed susceptible of explanation as a case of affective summation. On the face of it, however, so extreme a statement gives rise to the suspicion that introspection is here adding to the credit of feeling at the expense of sensation,⁵ and that the construction of Kröner and Lagerborg, who maintain that in such cases the sensation mass itself constitutes the feeling or affective tone,⁶ stands closer to the truth.

Some peculiar mechanism of transmission for higher intensities lies presumably at the root of the sudden jump which Weber, Wundt, Külpe and others assert to take place when organic sensation abruptly rises from this vagueness and indistinctness into pain of such violence and high affective value that accurate observation of it is impossible.⁷ The requisite conditions of such a mechanism might indeed be in part fulfilled on the hypothesis of a secondary conduction path offering considerable resistance to its more peripheral synapses, in its more central portions a low limen and considerable capacity for explosive and intensive functioning. Feebleness and violence, at any rate, appear alternately as the basis of explanation of the ease with which organic sensation customarily

¹ R. H. Lotze: *Medicinische Psychologie*, 281.

² H. Höffding: *Outlines of Psychology*, 1891, 225-6.

³ W. Wundt: *Physiol. Psychologie*, 1902, II, 42-4.

⁴ G. T. Ladd: *Psychology, Descriptive and Explantory*, 1894, 175, 184.

⁵ It is noteworthy in this connection that the four authorities quoted are all exceedingly liberal in their estimates of the variety and richness to be ascribed to the affective elements in general. They are also all more or less inclined to identify the distinctive feature of pain not as a sense quality, but as feeling moment superadded to or extinguishing the latter.

⁶ E. Kröner: *Das körperliche Gefühl*, 1887; R. Lagerborg, *op. cit.* See also A. Horwicz: *Zur Lehre von den körperlichen Gemeingefühlen*, *Vierteljahrsschrift für wiss. Philosophie*, 1880, IV, 273-310, for an excellent discussion of organic sensation as feeling, disposition or mood.

⁷ Wundt: *op. cit.*; Külpe: *op. cit.*, 140, 146; Weber: *op. cit.*, 22. According to Weber, this state of affairs is due, at least in part, to the lack of developed *Tastorgane* to protect the terminations of the internal nerves from over-stimulation.

eludes the attention. The possible neurological obstacles in the way of organic sensation as well as the query as to its essentially painful character will come up for discussion later. In the meantime, however, it is worth noting that the authorities quoted cite the high affective value and commotion produced by organic sensation in its supraliminal phases as irremediable obstacles to observation, without apparently pausing to consider whether the gap between liminal and violent organic sensation is actual and absolute, or merely the effect of the normal absence of any incentive to attend to intermediate intensities; all organic sensation possibly appearing liminal in its marginal vagueness until of a strength to secure its automatic admission to the focus of consciousness.

While the trait of unanalyzability has been in part ascribed to the defective and undeveloped functioning or lack of elaboration of the nervous mechanism, that of unlocalizability especially has been referred¹ to the central or general character of the adequate stimuli. If for instance the immediate effect of an alteration in the composition of the blood on the brain centres or on the peripheral nervous system as a whole constitutes the adequate stimulus, the operation of the ordinary mechanism of localization or reference becomes improbable. A word of caution is, however, here in order. While the tonic action in reflex centres of the condition of the blood is an accredited physiological fact, the direct effect on consciousness of such action is problematical. Therefore, even though the appeal to conjectural central processes is, in the absence of reliable introspective data and in the interests of special theories and classifications, admissible, such theorization can hardly be permitted to throttle investigation of the facts. The authority of this position is, moreover, weakened by the lack of any detailed working out of the hypothesis, or attempt at adjustment with current doctrines or facts, as *e. g.*, in Kröner's chemical theory, where, in defiance of the generally accepted doctrine of specialization or adaptation in the afferent nervous system and its central stations, absolute indifference of function is tacitly assumed.

In view of the absence of any definite experimental evidence against the possibility of observation and analysis the more hopeful attitude of certain psychologists is worth noting. Beaunis in especial is firm in the conviction of the possibility of training the attention upon the observation and singling out of internal sensations, while Meumann reduces their customary vagueness to indefiniteness of localization and the latter primarily to the absence of correlated visual images,² leaving

¹ Wundt: *op. cit.*, p. 43. Kröner: *op. cit.*, 28, 31.

² *Loc. cit.*

open the possibility of the application of other methods to the breaking up and clarifying of organic sensation.

Against the objection that organic sensations are not reproducible, give rise to no free images,¹ it may be also urged that the question remains open whether this defect is intrinsic to the neural mechanism of internal sensation, or transcendable through experimental methods and training. The whole problem of the possibility or impossibility of the investigation on this or other grounds is, of course, intimately bound up with the question whether visceral afferent impulses in general represent rudimentary, atrophied and vestigial sensation, or sense material the further development of which has been arrested, not inevitably impeded by functional or practical causes. We shall, therefore, in a succeeding section, have recourse to the natural history of organic sensation, in its biological, physiological, and histological phases, as a guide to the probable limits of profitable investigation.

2. *Existence of any organic sensation other than pain.* Common sense sanctions the recognition of a wealth of either actively pleasant or only mildly unpleasant organic experiences, hunger, satisfaction, satiety, and the like, yet clinicians, physiologists, and even a few psychologists, notably Wundt, have stubbornly asserted the essentially painful character of all visceral sensation. When, however, the basis for this assurance is examined, its negative and inferential rather than introspective character is quickly evident. In the case of the clinician an over-emphasis on pain is but the normal outcome of his preoccupation with surgical and pathological, *i. e.*, *painful* cases. This prepossession is strengthened by the insensitivity manifested by the viscera under surgical manipulation; the customary stimuli (mechanical, thermal, and chemical) of external cutaneous sensations (pressure and temperature) are here inoperative. Arguing by analogy with the skin, he therefore quickly arrives at belief in the non-existence of any painless phase of organic sensation. We need only pause here to point out the logical conclusion of argument upon these premisses, *i. e.*, the negation of all visceral sensation, painless and painful alike. The Swedish surgeon Lennander has indeed recognized the logic of this position, and achieved the *tour de force* of transferring all the responsibility for the so-called

¹ Cf. E. B. Titchener: *Organic Images*, *Journal Phil., Psych. and Sci. Meth.*, 1904, I, 36 ff. The objection is here raised as a protest against dogmatic assertions that any sensation, just because it is sensation, must be reproducible in image. The author finds evidence that at any rate in minds of certain types, certain organic sensations are not thus reproducible, and enters a plea for further systematic work on the subject.

“visceral” distress of disease and inflammation to the body wall, a doctrine which we shall revert to later. Others, while less extreme, are nevertheless sensible that on the line of reasoning above adopted the emergence of any organic sensation whatever, even pain, is an anomaly to wrestle with. Given the law of parsimony and the fact that the afferent impulses of the viscera do not normally reach consciousness, what explanation is possible of the neural mechanism by which in cases of exaggerated intensity or disease these processes in the guise of pain assail the attention? Would cortical connections functioning perhaps once, perhaps never in the lifetime of the individual persist in the race?

The answer to this problem furnished by Foster¹ is physiologically simple enough, though involving a dubious recourse to the subconscious, and will be touched on later. According to the more radical, however, the pain of disease represents in all probability a later development in the history of the race for the protection of the regions supplied by the older subconscious sympathetic system,² and is mediated by some makeshift of a mechanism, such as leakage from the sympathetic or vagus to the pain centres of the external system (Ross, Mackenzie, and Head), or the stimulation through excessive visceral activity or inflammation of nerve trunks of the external system which happen to pass near the organs or tissues affected (Lennander).³ The paradox of the apparent painful response of the viscera to external pressure in case of disease or inflammation is, moreover, generally reduced to a mere matter of the hyperalgesia of the body wall or skin (Mackenzie and Head).

With regard to the insistence of the surgeon on the non-existence of painless visceral sensation, it will be sufficient here to indicate not only the fallibility of observations conducted under such unfavorable conditions, but further, the inconclusiveness of argumentation on the basis of a doubtful analogy between skin and viscera. The fallacy involved becomes the more apparent when a similar line of reasoning is applied to the external muscle system. The insensitivity of muscle, tendon, and joint, many times demonstrated, probably long retarded the recognition of the ‘muscle sense’. Yet to-

¹ M. Foster: *Physiology*, IV, 284, according to whom pain is mediated by the ordinary afferent mechanism, and represents merely an exaggeration of afferent impulses which are continuously present but unnoticed. Another solution is presented by L. Oppenheimer who has pressed the vaso-motor nerves into service in explanation of internal as of external pain; see his *Physiologie des Gefühls*, 1899.

² J. Mackenzie: *Pain*, *Brain*, 1902, XXV, 384.

³ For further discussion and references, see below, Section B.

day the absurdity of a denial of the kinæsthetic sensations bound up with the normal functioning of those tissues would hardly be tolerated. There is every reason for assuming that the adequate stimuli of internal tissues are radically different from those of the external (the cutaneous in particular), being in all probability predominantly chemical in character, as the functions of the internal organs would imply. The doctrine of the insensitivity of the viscera, while in its limited clinical application a fact of prime importance, need therefore in cases of normal functioning carry little weight for the psychologist prior to more exact and extended observations.

Among the physiologists¹ the parallel doctrine of the essentially abnormal and painful character of any sensation in the viscera represents a tradition handed down from Weber and based primarily upon a somewhat hasty inference from the absence of protective 'touch' organs similar to those of the skin on the mucosa or endodermal surfaces and of the lack of temperature or pressure sensations in the more peripheral portions of the alimentary canal,² secondarily perhaps on the physiologist's tendency toward preoccupation with the purely vegetative and nonconscious functions of the visceral nervous system. In view of the counter evidence available on the introspective side in the writings of J. Müller, Bain, Sherrington, Helmholtz, Lehmann, Ebbinghaus, James, Beaunis, Titchener, and Meumann, we need not at this point enter into further discussion on the question.

3. *Plurality of Qualities.* For those who grant the possibility of painless visceral sensation, the terminological question of the variety of sense qualities, the number of tones, so to speak, in the organic gamut, next arises. In view of the general conviction that analytical methods are unavailing in this sphere, the distance covered by individual observers is worth

¹ Cf. Gruenhagen's *Lehrbuch der Physiologie*; W. Nagel's *Handbuch der Physiologie des Menschen*; M. Foster's *Physiology*; and W. H. Howell's *Text-book of Physiology*, 1906, all of which virtually ignore any quality other than pain. This is frequently, however, little more than an assertion of the essential difference between internal and external surfaces, and the lack of response of the former to environmental stimuli. When the physiologist happens to think of a true functional visceral complex, as hunger or nausea, he is usually moved to make an exception to his 'no non-painful visceral sensation' rule. Further, his concept of pain is largely physiological; pain is simply the harmful to the organism. Inasmuch as he is usually uncertain, on the psychological side, whether the painfulness of pain is a sensory or affective attribute, and intrinsic or adventitious, his applications of the term may frequently be misleading: his physiological pain may connote, on the psychological side, a quite indifferent sensation.

² *Op. cit.*, 562, 489, 497. See also Meumann: *op. cit.*, 43-47.

noting. A brief survey of the literature reveals the case as follows. In spite of the alleged inaccessibility of the organic factors to detailed examination, the general trend of opinion guarantees their uniqueness and variety—uniqueness as over against the qualities of the muscle-skin continuum, variety as among themselves, in virtue of their origin in different organs and tissues. The significance of this apparent liberality must, however, not be overrated; the above statement must be hedged in with certain reservations. In the first place, it must be admitted that, in individual cases, notably in the psychologies of Ladd and Wundt,¹ this class of sensations fares badly: the richness and variety of coloring ascribed to organic content are invariably inversely proportionate to the importance and variety attributed to the affective elements proper. In the second place, the significance of the unanimity above cited is greatly lessened when the varying rigidity with which introspective criteria and the concept of quality are applied by the different writers is taken into account. The varying importance and significance attached to the doctrine of specific energies here plays an important rôle. Laxity in regard to this principle is usually manifested in a tendency to accept off-hand any superficial difference, topographical or practical in origin, as qualitatively valid. In general, exact introspective evaluation and analysis is absent and classifications are based upon purely extrinsic data. Müller, Bain, Sherrington, Helmholtz, Ebbinghaus, James, Beaunis, Titchener, and Meumann admit plurality of organic qualities in some form or other, but with what discrepancy in the details! Müller,² *e. g.*, while conceding a variety of shading in visceral sensation, nevertheless unhesitatingly ranks it in the same sub-class with the external cutaneous and muscle sense elements, pressure, temperature and pain, themselves susceptible of many qualitative fluctuations and gradations. The remainder of the authors listed hold apparently to the uniqueness of the organic contribution as over against the muscle-skin continuum, but this can only be predicated with certainty of Titchener, Ebbinghaus and Meumann. In general, the 'divisibility of organic experience into two great categories, the pleasurable and painful, is admitted, but in the detail of further classification great diversity exists.

The prodigality with which Bain³ lavishes his sensory rubrics is especially conspicuous. Various forms of muscular, nervous, circulatory, respiratory, and digestive 'feelings' are

¹G. T. Ladd: *op. cit.*, 168; Wundt: *loc. cit.*

²Müller: *op. cit.*, 1324 and 1087.

³A. Bain: *Senses and Intellect*, 1864, 118ff.

cited, and the peculiar attributes of fatigue, exhilaration, depression, suffocation, hunger, satiety, nausea, and various other bodily comforts and discomforts described in general terms. Comparison or detailed analysis is, however, not attempted, with the result that ramifications overlap and the classification remains of dubious value except as a testimonial of the author's absorbing interest in the subject.

Beaunis'¹ voluminous schema is likewise unreliable, based as it evidently is on a half dozen different principles of classification. Differences in the way in which sensations come to consciousness, variations in their mode of origin or occasion of appearance (*i. e.*, in the normal exercise of function, in premonition of organic needs, or in surgical manipulation), their pleasant or painful character, rather than observed qualitative distinctions form the *raison d'être* of his eightfold division. The casual character of the classification stands revealed in the headings, 'organic sensibility', 'organic needs or cravings (*besoins*)', 'functional sensations', 'cœnæsthesia', 'emotional sensations', 'specific sensations', 'pain', and 'pleasure', which obviously indicate groupings or points of view significant to the physician or biologist, but hardly to the psychologist. While Beaunis is usually quoted as having testified to the plurality of organic qualities, he really never comes to close quarters with the question, but concerns himself, as a matter of fact, almost exclusively, with the determination of the number of the internal tissues sensitive, and the extent of the rôle played by organic, more especially, *muscle* sensation, either in its conscious or subconscious phases, in all adjustments of the organism.

Horwicz seems to occupy a position midway between those of Bain and Sherrington. While apparently admitting specific sense qualities, he maintains that many of them are obscure and indescribable.²

Sherrington,³ though primarily interested in the problem of pain, admits the existence of many organic sensations both pleasurable and painful which are far from obscure. Both functional activity and the call for repetition of this activity are plainly conscious, although they must remain forever indescribable in virtue of the fact that the physical offers no adequate and unequivocal ultra-individual symbols for these

¹ H. Beaunis: *Les sensations internes*, 1889, 3.

² A. Horwicz, *op. cit.* See also J. Sully's review, *Mind*, 1882, VII, 302-3.

³ C. S. Sherrington: in E. A. Schäfer's *Text-book of Physiology*, II, 971-3. There is also in "The Integrative Action of the Nervous System," 1906, 130, an implication that the 'proprio-ceptive' qualities of the deeper tissues are specific.

sensations. The variety of organic sense qualities is, however, in this discussion an implication merely. In view of the tendency occasionally appearing among physiologists to identify pleasantness and unpleasantness with pure sensory qualities (*i. e.*, the physical sensations of pleasure and pain), it is interesting to note that Sherrington, along with the three preceding writers quoted,¹ may perhaps best be described as regarding organic sensations as modes or shades of the two basic qualities of bodily comfort and discomfort.

For Ebbinghaus,² the sensory contribution from the internal tissues is as varied and extensive as for Bain. Hunger, thirst, satiety, discomfort, nausea, fatigue, energy, oppression, suffocation, buoyancy and the like are listed as arising from the digestive, muscle, and respiratory systems respectively, along with certain more diffuse organic states, such as excitement, unrest, relaxation, depression, dullness and drowsiness, the probable origin of which is assigned to changes in the circulatory system. The question of the possible complexity, similarity or relationships of these states is not raised. The implication is that each represents a specific sensation peculiar to the system from which it arises, each organ possessing '*eigenartige Empfindungen*'. Further, sensitivity to pain is declared to be lacking only in connection with the substance of the brain, and the mucosa of the intestines and stomach.

Titchener (see J. M. Baldwin's Dictionary of Philosophy and Psychology, II, 218) distinguishes, apart from skin and kinaesthetic sensations, a number of organic qualities for which the alimentary canal, circulatory, and respiratory systems are held responsible.³

Meumann,⁴ in a recent article, has expressed himself in favor of a great multiplicity of organic sensations (*innere Tastempfindungen*), on the basis not only of the *a priori* argument of origin in different organs and tissues—unstriated muscle, serosa, glands, capillaries, the alveoli of the lungs, etc., and of usefulness to the organism, but also as the result of his own carefully recorded introspections and of certain observations of d'Allonnes. This qualitative diversity is obscured, he maintains, only by the indefiniteness of localization of the

¹ Weber and Kröner might be included in this list.

² H. Ebbinghaus: *Grundzüge der Psychologie*, 1902, I, 426-32. The 'Abriss der Psychologie', 1908, p. 49, contains perhaps the most positive statement in the whole literature. "Die durch sie vermittelten Empfindungen stehen ebenso selbständig und eigenartig nebeneinander und neben den übrigen Empfindungen wie Farben neben Tönen und Geschmücken."

³ See the same author's *Primer of Psychology*, § 21; *Text-book of Psychology*, §§ 56 ff.

⁴ *Op. cit.*, 56-8.

sensations, and their deficiency in correlated visual images by which qualitative isolation might be facilitated.

James, while assigning tremendous importance to organic sensation and expressly stating that at least for pain the 'internal organs have their explicit qualia of sensation just as different areas of the skin have their respective local signs',¹ contents himself characteristically with the assertion that 'our whole cubic capacity is sensibly alive',² and with casual references to 'precordial anxiety', the 'euphoria arising from the respiratory organs', to the 'pang in the breast', a 'fullness in the breathing', etc., without at all committing himself to the composite or elementary character and specific differences of these bodily symptoms. It is further to be noted that a large proportion of the physiological 'reverberations' reported by him as constituting emotion are obviously cutaneous and muscular rather than visceral.

Finally, there is a small group of writers, who, while attributing a certain diversity to organic sensation (*i. e.*, not limiting it strictly to the category of pain), recognize its close kinship if not identity with the external (cutaneous and muscular) continuum. In this class belong Müller, Külpe, Goldscheider, and Calkins,³ all of whom are inclined to find in the quality of pressure a sufficient explanation for all visceral complexes. A similar tendency to posit a single muscle quality common to both skeletal and visceral tissues may also be noted. Weber, Bain, and Beaunis may here be mentioned, although the most explicit statement occurs perhaps in Lagerborg.⁴ Lagerborg himself, however, is unwilling to commit himself unconditionally to the identity of this quality in the external and internal tissues, owing largely to the differences in the minute structure of the latter. As a matter of fact this phase of the question seems to have rested so far on anatomical rather than psychological observations and comparisons.

In conclusion, it must be admitted that there is nowhere in the literature any consistent attempt to indicate similarities

¹ W. James: *Principles of Psychology*, II, 156.

² *Op. cit.*, 451.

³ Müller: *loc. cit.*; Külpe: *loc. cit.*; Goldscheider, *Gesammelte Abhandlungen*, I, 1898, 47-8; M. W. Calkins: *Introduction to Psychology*, 1901, 84-6. Mention may here also be made of E. Becher who has recently on the basis of certain experimental observations on the stomach and œsophagus (see *Zeitschrift f. Psych. und Phys. d. Sinnesorg.*, 1908, XLIX, 341 ff.) arrived at the conclusion that feeble sensations of warmth, cold and pressure may be obtained from the œsophagus, and that all the other viscera are probably insensitive. The sensations usually ascribed to the viscera are either centrally excited or arise from the peritoneum, pleuræ, diaphragm, or body wall (hence are presumably closely related to the external continuum).

⁴ *Op. cit.*, 16 and 17.

and relationships in the states under discussion, nor is there even any substantial agreement in the use of single terms. Hunger, *e. g.*, is identified by Kröner with a diffuse, unlocalizable feeling (preferably, faintness), by Sherrington and others with a localized sensation mass in the epigastrium. Neither, moreover, is there any light shed upon the subject of specific liver, kidney, lung or heart sensations in the discussion of psychopathic or emotional cases by Störing, Kraepelin, Janet or Lange, as we had hoped. It is plain that the solution of the problem of a scientific terminology and descriptive basis for organic sensations must be preceded by a more minute examination than has yet been attempted (in any of the authors quoted) of the sense material concerned; and especially by a detailed comparison of visceral with external (kinæsthetic and cutaneous) sense qualities. Such a procedure should, at the very least, establish some large likenesses or unlikenesses (other than pleasantness or unpleasantness) which may serve as the basis of a stable classification.

Summary. While, on the testimony above cited, the existence of a large body of sensations not usually externally referred is incontestable, the precise significance of this fact remains to be determined. The ground of distinction between organic and special sense experience stands greatly in need of definition.

The fusability, absence of memory images, unanalyzability, lack of cohesiveness with other sensations, unlocalizability, capacity for eluding the attention, and other features ascribed guardedly or confidently in various quarters to our organic experience, demand critical verification. Finally, whatever may be the actual status of these sensations, the investigation of what represents apparently the least developed and systematized sphere of our consciousness may reasonably be expected to throw a new light upon the processes of localization and attention. Even though the results of this study should fail to assist in the solution of any psychological problem, a systematic account of these processes and their localizability in the normal subject may be not without value to the pathologist and clinician.

HISTOLOGICAL, PATHOLOGICAL AND PHYSIOLOGICAL EVIDENCE

An investigation of the psychology of internally initiated sensation can hardly be undertaken without first attempting to stake out the possibilities in keeping with neurological conditions. As already indicated, such problems as the differentiation of qualities and the range of sensitivity in the internal tissues, of the possibility of localization and analysis,

and the significance of the former, are clearly related to the histological problems of the variety and distribution of afferent nerve endings and the possibilities of diffusion inherent in the peripheral or central neural mechanism. A brief survey of the literature of the sympathetic system and the sensory innervation of the internal tissues has accordingly been undertaken and the consensus of expert opinion upon the number of tissues sensitive, kinds of endings, relative fewness or multiplicity of nerve fibres, conduction paths, brain centres, and the like collated. For information upon the immediate and remoter origin of internal sensation, according as determined directly by chemical or mechanical changes in the circulatory or muscular tissue, or indirectly through the medium of reflexes or irradiation in the central system, recourse has been had to physiology.

The result has proved somewhat disappointing. Authenticated knowledge of the sensory endings in any given tissue and their conduction paths from periphery to cortex is meagre. Direct evidence based on the results of degeneration or experimental stimulation of the nerve elements figures to a surprisingly small extent and is eked out largely by inference from more or less ambiguous introspective data. *E. g.*, the existence even of afferent endings in plain muscle tissue is argued from the fact of locally referred pain in renal and biliary colic. The insecurity of any conclusion based on such premisses becomes apparent in view of the doubt cast upon the trustworthiness of localization by certain clinicians and pathologists, *viz.*, Mackenzie and Head, in their doctrine of referred pain. The need not only of a more thorough-going exploration of the centripetal paths through the posterior root ganglia and cord but also of a more cautious use of the facts of apparent localization, will become apparent as we proceed. On the whole we can extract from histology in its present status very little evidence bearing directly on organic sensation. So far as sensory in distinction from afferent innervation of the tissues is concerned, psychology is largely thrown back upon her own resources.

With regard to the evidence of pathology, the question raised by Mackenzie whether internally initiated sensations have central pathways and end-stations in their own right, or are dependent for access to the higher (*i. e.* conscious) centres upon pathways borrowed from the sensory system of the body wall, is an important one. Its bearing upon the existence of unique and specific sensory qualities in the viscera is, in view of the current assumption of the all-importance of the end-station and the indifference of the process in the nerve fibre, obvious, and will be examined in some detail.

A. ANATOMICAL AND HISTOLOGICAL

1. *End-organs in internal tissues.* Only two kinds of receptive tissue¹ have so far been described in the internal organs, the free sensory endings and the Vater-Pacini corpuscles. Of these, the latter (which occur also in the dermis of the hand and foot, near the joints, in the periosteum of certain bones, in tendons, intermuscular septa, and even in muscle) are found in the epineural sheaths of certain nerve trunks and near large vessels, and are numerous in the peritoneum, mesentery, pleura and pericardium.² The free sensory endings, which are usually branching and nodulose, are found in epithelial, connective and plain muscle tissues, and are distinguished from motor endings mainly by terminating on, rather than in, the muscle fibre.³

The bearing of this limited differentiation of sensory endings on the question of the number of specific differences in organic sensation is of course debatable. If we accept the theory of specific energies, which maintains that the nerve process excited in any peripheral fibre by a physical stimulus is *per se* indifferent, *i. e.*, of one kind only, and that even if the nerve fibre itself is excitable by a wide range of stimuli known as common stimuli (thermal chemical, mechanical, electrical, etc.), mere difference in character of the stimuli is not sufficient to secure differentiation of sensory response, but that the latter presupposes an elaborate neural evolution in which appropriate end-organs to select one form of stimulus, and protect the nerve ending from all other forms are developed along with a central mechanism for securing differentiation in consciousness of the corresponding sensation,—if we accept this hypothesis in all its strictness, the implication for organic sensation is of course pretty straightforward: evidence for a plurality of organic sense qualities is lacking. Two objections to such a conclusion may, however, be raised. First, it is not improbable that further histological research may discover slight differentiations in the chemical composition if not in the structure of the

¹A possible third is represented by the occurrence in the mucosa of the ileum of fibrils terminating on or near nerve cells similar to tactile corpuscles. Poirier et Charpy: *Traité d'anatomie humaine*, 1901, IV, 92.

²A. A. Böhm, M. von Davidoff, and G. C. Huber: *Textbook of Histology*, 1904, 174. It is unfortunately not always clear whether human or mammalian tissues in general form the basis of such deductions.

³There is, however, a difference of opinion here. G. C. Huber maintains that the motor fibre itself ends *on*, not in, the muscle fibre, leaving the sensory-motor distinction the more in doubt. Cf. *The Sympathetic Nervous System, Journal of Comparative Neurology*, 1897, VII, 192.

tissues in which the nerve fibres end or in the terminal nodules themselves, such as to render them specifically adapted to the chemical reactions or substances peculiar or significant to the tissues in which they occur. The fact that a relatively small variety of end-organs has been discovered in the mucous membrane of the mouth which nevertheless possesses a sensitivity to temperature, pressure, and pain (not to mention taste) as acute or more so than that of the external skin, lends color to this hypothesis. Secondly, the tendency is now showing itself to abandon the doctrine of the identity of the nerve process in all fibres and the more rigid conception of specific energies, and to suggest, what indeed was the older view, that the range of excitability of a single nerve fibre may include stimuli slightly different in quality, each of which is capable of giving rise to its own peculiar nerve impulse, which when transmitted to the centre may be sensed as an individualized sensation quality.¹ Apply this doctrine to the free sensory endings of the viscera, and the impossibility of an extended gamut of related organic qualities vanishes.² In the absence of any deterring histological or physiological evidence, we may at least admit that the field remains open to psychological exploration and experiment.

2. *Distribution of afferent innervation.* The occurrence of 'sensory' nerve fibrils in the epithelium of the bladder, œsophagus, tongue, lung, liver, pancreas, stomach, intestine and the like; in the connective tissue of the heart, lung, and eyes, of the dura mater, and of certain mucosa; and probably in the plain muscle tissue of the hollow viscera (heart, intestine, ducts, glands, etc.) is maintained by Barker³, and more or less substantially sustained by Böhm, by the anatomists Poirier and Charpy, and by various others with certain reservations. It is to be noted, however, that the term 'sensory' is to a certain extent used interchangeably with 'afferent', and that the classification of a nerve as sensory is in many cases based merely on the supposedly non-motor character of the endings, unsupplemented either by the tracing of the fibre back to the posterior root ganglion, or the testing of the stump for pain. Further caution is suggested by the possibility that many of the fibrils listed, even if not motor or secretory, represent nerves concerned only with the mediation of reflexes in the cord or lower centres, and incapable of projecting a sensory

¹W. Nagel: *op. cit.*, 13, 15.

²As a third possibility we might suggest the structural degeneration of the end-organ, after a functional and central differentiation had become established.

³L. F. Barker: *The Nervous System and Its Constituent Neurones.*

impulse to consciousness.¹ The evidence and line of argument by which the neurologist or physiologist arrives at his conclusions must therefore be scrutinized in detail.

The general method of procedure by which the afferent or sensory innervation of the various tissues is established is as follows. Gross anatomical and experimental methods come first in point of time. The stumps of the general nerve supply of any region were tested by the early anatomists, either for outward evidences of pain, or for simple reflex discharge in related motor channels, and inferences on the sensitivity or insensitivity of the tissues innervated made accordingly. Thus the insensitivity to pain of the sympathetic nerve as tested in the experiments of Magendie was assumed to establish the insensitivity of the innervated tissues, notably the intestine and its outlying glandular systems,² while the sensitivity of the stump of the vagus was, on the contrary, assumed to indicate the sensitivity of the region of its peripheral distribution, inclusive of heart, lungs, and stomach in particular. The ambiguity of tests of this type is readily apparent. The test based upon the stimulation of the stump for pain symptoms is valid only for pain nerves and overlooks the possibility of the presence of non-painful sensory fibres, at the same time that it ignores the probability that the adequate stimulation of visceral fibres is serial, intermittent, and summing. Even the success of the test in eliciting evidences of reflex action indicates at best the existence of a reflex arc through the cord or lower centres.

As a matter of fact, later application of these very tests has resulted in the reversal of Magendie's findings. Evidences of pain following stimulation of the sympathetic (through the coeliac or solar ganglia, or the splanchnic nerve) have been demonstrated by Flourens, Brachelt, Mayer, and Müller.³ Indeed, to-day the responsibility for pain in organs below the diaphragm (the stomach, liver, and pancreas in particular) is usually shifted to fibres reaching these organs via the sympathetic rather than the vagus,⁴ although the innervation by the two systems is to a large extent overlapping. In general, however, with refinement of methods and a growing discrimi-

¹The possibility that even purely afferent or reflex fibres may under conditions of excessive stress borrow from other systems a path to the higher centres will be examined later. The normal sensory functioning of the fibres is alone here in question.

²The innervation of the intestine by both sympathetic and vagus (*cf.* Langley) was evidently not then recognized.

³Müller: *op. cit.*, 646, 705, 711 ff. These tests were usually, of course, performed upon animals.

⁴*Cf.* J. N. Langley: The Autonomic Nervous System, *Brain*, 1903, XXVI.

nation in the use of the terms affective and sensory, the tendency has sprung up among neurologists to distrust the sensory function of any fibre travelling with the sympathetic unless its passage direct from the posterior root ganglion *through* the sympathetic ganglia without termination can be demonstrated or inferred. That is, the only clear title of any fibre to sensation lies, histologically speaking, in its claim to enrollment as a cerebro-spinal fibre. On this basis the bias for the sensory innervation of the tissues supplied by a cranial nerve such as the vagus (the thoracic viscera and stomach especially), or by a spinal nerve, as the phrenic (arising from the third to fifth cervical roots and supplying the pleuræ, pericardium, and diaphragm),¹ is strong. Further, the demonstration of individual cerebro-spinal fibres (*i. e.*, of fibres passing without interruption from the posterior root ganglion cells to peripheral terminations in visceral tissue) in the sympathetic plexuses,² and the observation that certain histological peculiarities characterize such fibres, have suggested a practical basis for the distinction of afferent from efferent fibres (more particularly of sensory from

¹ K. Hasse: *Handatlas d. sensiblen und motorischen Gebiete der Hirn- und Rückenmarksnerven*.

² The fact that practically no afferent fibres occur in the gray rami by which efferent fibres of sympathetic origin return to the spinal system for distribution to the body wall, which must therefore draw its afferent or sensory supply directly from spinal ganglia (P. J. Cunningham, *Textbook of Anatomy*, 704), has led to the hypothesis that a large number of the afferent fibres of the viscera, in homology with those of the body wall, do not reproduce the course of the efferent autonomic system and terminate in sympathetic ganglia, to resume their course in the form of dendritic or axone fibres from sympathetic cells, but behave in every way like ordinary sensory nerves. Kölliker (*cf. Quain, Elements of Anatomy*; 350.), Gaskell (*Journal of Physiology*, 1886), Huber (*Journal of Comparative Neurology*, 1897, VII, 131), and Langley (Schäfer, *op. cit.*, 687), all recognize the presence in the sympathetic strands of a number of these (strictly speaking) *non-sympathetic* or *cerebro-spinal* fibres, having their trophic centres in spinal ganglia.

From this point of view the sympathetic ganglia would, of course, possess no automatic or reflex functions but represent merely a provision for the wider distribution of the sphere of influence of all preganglionic efferent elements, most of which end in relation with several different ganglion cells. To be sure, certain histologists, notably Dogiel, maintain the presence in the sympathetic ganglia of sensory or afferent cells, the axones of which end in association with efferent cells in the sympathetic system or cord to form reflex arcs. Schulze, moreover, finds among smooth muscle fibres sensory ganglion cells with one long central process, which, he suggests, is ordinarily concerned with the mediation of reflexes (presumably in sympathetic ganglia), but in cases of muscular spasm may give rise to pain. Lenhossek is also of the opinion that the sympathetic ganglia represent either relay or terminal stations for certain of the sensory fibres (Huber, *op. cit.*). The evidence on these points is, however, insufficient, and even if such a condition of things exists it obviously holds good only for a small proportion of the afferent fibres.

merely afferent), and for a more accurate discrimination of sensitive from non-sensitive tissues.

The marks by which the character of any nerve as cerebro-spinal and afferent, hence presumably sensory in function, are established, are three. First, the degeneration test, by which continuity of the fibre in its complete course from posterior ganglion to endings in any tissue is traced. Of evidence collected in this fashion there is only too little. Such as does exist points to the sensory innervation of the mesentery and the peritoneum (where the fibres end in Pacinian bodies), and of the bladder (in the frog).¹ Secondly, medullation of the fibres,² and thirdly, their large size or diameter. Neither of these last criteria is held to be absolutely valid in itself. They are, however, accepted as indicating the sensory character of the nerve endings in blood-vessels, heart, dura and pia matter,³ bladder, gall-bladder and mucosa of the intestines.⁴

With regard to the more minute histological indications of differentiation, the presence of free nerve fibrils in non-motor or non-secretory tissue (connective or epithelial) is assumed to represent afferent or sensory innervation. This applies to the vascular tissues, to the bladder, intestines, and endodermal or epithelial tissues in general.⁵ On the other hand, such free fibrils as occur in the walls of hollow muscular organs—the alimentary canal, biliary and renal ducts, blood vessels, heart, etc.—are distinguishable from motor endings by minor characteristics only,⁶ and their sensory function is largely inferred from the apparent sensitivity of these tissues in colic, renal and biliary inflammation, angina pectoris, migraine, etc.⁷

¹ Huber: *loc. cit.*

² It is a generally accepted fact that only post-ganglionic fibres—*i. e.* the fibres taking origin in ganglionic cells and representing the post-ganglionic continuation of the paths of fibres which have terminated around these cells—are unmedullated. Since this is known to be the rule with efferent sympathetic nerves and since many medullated fibres have been traced back to the dorsal ganglia, the *a priori* assumption is usually made that a medullated fibre in the peripheral twigs of the sympathetic represents an afferent or sensory neurone of the spinal system.

³ Böhm, Davidoff and Huber: *op. cit.* Sensory endings in the fibro-elastic tissue of many vessels, their endings beset with varicosities, have been recently demonstrated by Dogiel, Schemetkin, and Huber (p. 223). For endings in the inner lining of the larger vessels and in the endo and pericardium, see p. 215; in the dura mater, p. 437.

⁴ Stöhr: *Lehrbuch d. Histologie.*

⁵ Van Gehuchten: *Anatomie du système nerveux*, 1901, II, 531. See also Stöhr: *op. cit.*

⁶ Cf. Schultz: *Die glatte Musculatur der Wirbelthiere*, *Archiv. f. Anat. u. Physiol.*, 1895.

⁷ Barker: *op. cit.* See also Huber (*op. cit.*) for the suggestion that this line of reasoning is misleading, especially in view of the fact that sensory fibres have been traced into the *epithelium* of certain of the hollow organs.

The first line of argument overlooks the possibility that the fibres may be trophic in function, the second, the probability that other (sensitive) tissues than those immediately concerned in contraction or spasm may be involved. In itself, it is obvious, either line of reasoning goes only a short way unless supported by the system of experimentation and inference outlined above.

In summary, it must be granted that there is hardly a tissue in the interior of the body (mucosa, serosa, or plain muscle fibre) which may not be regarded as possessing an afferent, and thus potentially, a sensory neural equipment. Further, a number of minor lines of evidence converge to indicate the sensory function of this equipment in a large number of these tissues. That for the plain muscle fibres is perhaps the weakest.

According to the calculations of Langley, the proportion of afferent to efferent fibres in the sympathetic system in general is about one to ten. While this seems to corroborate Weber's reference of the feebleness of internal sensation to the fewness of the innervating fibres,¹ it is perhaps more accurately represented as a device for the intensification of the internal sensory impulses through summation. The branches of a single fibre are distributed over a wide area, and the neural effect due to the stimulation of a large number of terminal fibres is thus presumably concentrated in a single centripetal impulse. Further, a large number of the viscera (the thoracic organs, stomach, liver, intestines, and probably liver and pancreas in particular) receive a double afferent innervation, *i. e.*, from both vagus and sympathetic.²

3. *Pathways of visceral impulses in the spinal cord.* While the peripheral equipment of the internal tissues appears thus to extend almost indefinitely the possibility of sensation, a further question arises as to the provision for the transmission in isolation and in their full strength, of the sensory impulses to the cortex. First, does the afferent neurone possess a clear pathway in its own right to the cortex (and hence to consciousness) as does for example the sensory neurone from the exterior; or does its axone terminate in association with motor cells in the cord or lower centres, if not actually in a sympathetic ganglion, thereby indicating the function of the neurone to be merely reflex?³ Secondly, even if a clear centripetal

¹ *Op. cit.*, 491.

² *Op. cit.*, 29.

³ As would apparently be demanded by J. Müller's conception of the afferent sympathetic. See *op. cit.*, I, p. 723 f., where he suggests that visceral impulses are unconscious not because suppressed by sympathetic ganglia (Reil's suggestion), but because they function in the mediation of reflexes, and are accustomed to 'sich ausgleichen' in the cord.

pathway may be assumed, are there no peculiarities intrinsic to the afferent sympathetic neurone (such, *e. g.*, as the absence of medullation, the multipolar character of the cell bodies and the complexity of their terminal fibre connections) which make for diffusion, poor localization, or feeble intensity?

With regard to the first question, the fact that the afferent 'sympathetic' supply to the unstriated muscle fibres, glands, and blood vessels of the skin and body wall demonstrably does not even pass through a sympathetic ganglion but emerges directly from the posterior ganglion to join the postganglionic efferent fibres supplying the same general region, lends color to the probability that the homologous system of internal afferent fibres is quite like ordinary cerebro-spinal nerves, and that an unbroken and medullated course from the posterior ganglion to their final peripheral division into terminal fibrils may be predicted for them. As a matter of fact, so far as an actual examination of the state of affairs has been made, by means of the degeneration method or the tracing of medullated fibres to the very periphery, the evidence goes to show that the majority of the afferent fibres of the white rami communicantes (the visceral branches of the spinal nerves), and their peripheral continuations have their trophic centres in the posterior root ganglia just as do the cutaneous sensory fibres, and enter into no actual connections with sympathetic ganglion cells.¹ Further, experimentation has thus far failed definitely to demonstrate reflex action in any sympathetic ganglion,² hence the probability that the afferent fibres neither end themselves in sympathetic ganglia, nor give off any branches for that purpose, but afford a direct pathway to the cord with no opportunity for the shunting off of the sensory impulse into peripheral reflex paths, is materially strengthened.

The question whether the route through the posterior sensory ganglia is uninvolved and in all ways similar to that of an ordinary sensory neurone, *i. e.*, interrupted by one cell body only, is answered in the affirmative by Langley, on the basis both of histological demonstration and the fact that the number of fibres on either side of the ganglia is the same. The feebleness of sensations from the interior is due probably to high liminal values and fewness of nerves rather than to friction in peripheral paths.³ Barker, however, thinks it probable that the sensory impulses collected by means of sym-

¹Langley: *loc. cit.*; Cunningham: *op. cit.*, 704; Kölliker in Van Gehuchten: *loc. cit.*; Huber: *op. cit.*, 131.

²Exception must possibly be made here of such peculiar peripheral structures as the plexuses of Meissner and Auerbach in the alimentary canal.

³Brain, 1903, XXVI.

pathetic neurones pass through a chain or series of individual neurones before arriving at a primary end-station in the cerebro-spinal system.¹ Their fate after joining the dorsal roots of the spinal nerves he admits is unknown, but suggests that some of the sympathetic axones end within the spinal ganglia around the bodies of spinal ganglion cells, and that others pass directly through into the cord. As a matter of fact, Cajal has reported the ending of sympathetic fibres in branches about spinal ganglion cells, and Dogiel asserts that certain sympathetic fibres (which he assumes arise from sensory sympathetic ganglion cells) end about posterior root cells of a new type—small, and with a branched axone, the branches ending in association with a number of ordinary unipolar cells.² The evidence on these points is, however, casual and unsupported: Langley's position represents the larger body of facts.

With regard to the further pathway of the afferent impulse through the cord, Langley suggests two possibilities.³ A certain number of the visceral afferent fibres in all probability serve only to mediate reflexes to autonomous tissues, and are incapable of giving rise directly to sensation,⁴ while all the rest are sensory. The distinguishing histological characteristics of the two are yet to be determined, but presumably the upward paths in the cord are poorly developed in the case of the former. It is elsewhere suggested by Langley⁵ that the large medullated fibres ending in serous membranes are probably the ones which give rise to (direct) local pain; while the small fibres (ending in connection with unstriated muscle and glandular tissue) give rise to referred pain, that is, acquire an upward pathway and a sensory function only under very unusual conditions.

With regard to the provision in the gray matter of the cord for the transfer of irradiation from visceral to cutaneous fibres (in case of referred pain), there is at present no satisfactory evidence, as Langley admits. Even the irradiation from fibre to fibre of the sympathetic to which Müller⁶ had recourse in

¹ *Op. cit.*, 553.

² *Cf.* Van Gehuchten: *op. cit.*; also Schäfer: *op. cit.*, 686.

³ *Op. cit.* M. Meyer's suggestion for *pain* paths of the external and internal systems, *i. e.*, their convergence into fewer and fewer neurones as they pass up the cord, thus eliminating the possibility of exact localization of sensation, seems to find no direct support in the histological literature. See Der Schmerz, 1906, 74.

⁴ Mackenzie's hypothesis (see above) would seem to demand the ending of *all* visceral afferent axones in the lower motor centres, and the total absence of centripetal pathways past these centres to the cortex, sensation being effected only through the leakage in the cord to sensory neurones of the *somatic system*.

⁵ Schäfer: *op. cit.*, 686.

⁶ *Op. cit.*, I, 723 and 680.

explanation of the vagueness and indefiniteness of localization of organic sensation has found so far no basis in the anatomical peculiarities of the afferent sympathetic neurones. Neither absence of medullation in the peripheral fibres, nor the multipolar type of cell peculiar to the efferent sympathetic neurone, is characteristic of the afferent.

Lastly, with regard to the representation of visceral sensation in the cerebral cortex. In general, no reference of visceral sensation to cortical centres has been attempted. The projection of visceral fibres above the medulla seems to be unknown. Even for cutaneous pain no end-station higher than the optic thalami has been demonstrated. Sollier,¹ however, maintains on the evidence of experimental and pathological cases the existence in the parietal lobe (generally given over to the 'stereognostic' sense) of centres for the stomach, intestines, heart, respiratory apparatus, genital organs, and bladder. Ferrier, on the other hand, names the occipital lobe as the recipient of excitations from the viscera. Further research is obviously in order before the question can be satisfactorily settled. Even if, however, the projection of visceral paths beyond the lower centres of the brain should not be demonstrated, and the inaccessibility of visceral impulses to the cortex (except through borrowed paths, as pain) were admitted, the possibility would still remain that consciousness is not limited to any rigid correlation with the cerebral cortex, but accompanies also the activity of the lower centres, and that even the feebler visceral impulses may thus attain a dim sort of consciousness.

Our survey of the histological and anatomical evidence for organic sensation brings us, therefore, to the following conclusion. Although the number of afferent fibres to the viscera is relatively small, their distribution is wide and the corresponding possibility of sensitivity considerable. While on the whole the probabilities are against any extensive differentiation of organic sensation, the possibility that non-painful sensations of some sort or other may reach consciousness from the viscera remains practically uncontroverted. Further, no insuperable obstacle to successful observation and analysis has been demonstrated in the histological conditions of the centripetal pathway. It remains, of course, to examine the limitations on the physiological side which may possibly be established by a study of the experimental, pathological, and clinical evidence.

B. PHYSIOLOGICAL. THE CONDITIONS AND FUNCTIONS IN THE ORGANISM OF ORGANIC SENSATION

I. *Adequate stimuli of afferent nerves in internal tissues.* Among the possible stimuli, mechanical and chemical, the

¹P. Sollier: *Le mécanisme des émotions*, 1905, 215-7.

following first suggest themselves. The contact or friction on mucous surfaces of food substances, secretions, excreta, etc., on serous surfaces of heavy or distended viscera; the intercellular pressure from dilated blood vessels, or distended gland cells in certain tissues; the distension of ento- or meso-dermal linings (in the stomach, bladder, ducts, blood vessels, alveoli, etc.) by gaseous or fluid contents (operating probably through the stretching of the afferent nerve fibres of these tissues); and the compression through muscle contraction of the endings in the walls of hollow muscle organs (heart, stomach, certain blood vessels, ducts, etc.). Further, the chemical properties of entering substances (food, air, etc.), the drying of the epithelium of stomach and pharynx, the presence of fatigue or toxic products in the tissues, and the varying consistency and chemical attributes of the blood may be mentioned.¹ Of these the physiologists specifically recognize (on the ground of their efficiency in the production of visceral reflexes) the following: distension of lung tissue in inspiration,² mechanical stimulation of food in the œsophagus, stomach, etc.,³ of foreign or pathological substances in the respiratory entrances and secretory ducts, compression through muscular contraction (effective in vaso-dilator reflexes), the chemical properties of the blood in the cavity of the heart,⁴ or distension of the latter, noxious gases at the entrance of the lungs,⁵ and chemical properties of food or the acidity of the contents of the stomach (effective in the production of secretion, nausea, peristalsis, and the like).

The question whether these stimuli act upon nerve endings specifically adapted to receive them, or whether they belong merely to the class known as common nerve excitants, *i. e.*, are capable *per se* of acting directly upon any nerve fibre they may encounter, is a difficult one. In the former case the possibility of reducing all the excitants listed to a single closely related class, *i. e.*, mechanical (in which case chemical irritants would act only through direct attack of the nerve substance) or chemical (distension would then represent *inadequate* stimulation through stretching of the axones) may be mentioned, and will be referred to later.

2. *Adequate stimuli of internal sensation.* There is general agreement that the mechanical sensibility of the viscera differs radically from that of the outer integument. There is in the

¹ The fact that the viscera are customarily rated *insensitive* to many of the above has no immediate bearing on the point here under discussion, the excitability of afferent, rather than merely sensory, visceral endings.

² W. H. Howell: Text-book of Physiology, 1906, 617.

³ *Op. cit.*, 645-6, 648.

⁴ *Op. cit.*, 501.

⁵ *Op. cit.*, 625.

deeper tissues no 'contact' sense homologous to that of the skin. The adequate stimuli of internal sensory nerves are physiological rather than physical; they are pre-eminently functionally or reflexly initiated excitations, whether ultimately represented by chemical or mechanical agencies. The impinging of the outer environment in the form of food, air, etc., is as a usual thing indirectly if at all sensible, *i. e.*, in the form of reflexly excited activities which represent not the objective properties of the stimulus, but the effect of the latter upon the organism. Contact or pressure on the inner mucous surfaces is, for instance, effective only in the reflex excitation through autonomic ganglia¹ (plexuses of Meissner and Auerbach) of secretion of digestive juices, peristalsis of the digestive tract, etc., which in turn are probably conscious only when excessive.² An exception to this rule must possibly be made in favor of substances producing distension of hollow organs, and thus directly affecting their intrinsic nerve fibres through stretching, as in cases of too rapid swallowing and the lodging of a morsel of food in the œsophagus, or in over-distension of the bladder, stomach, or arteries.³ It is to be noted, however, that even here not mere presence or pressure of the disturbing substance, but actual distension of the tubes is apparently necessary, and, further, it may be only the resulting muscular reaction of the walls which comes to consciousness. Similarly, the effects of certain exogenous chemical substances, such as the feeling of suffocation produced by certain noxious gases, or the nausea attending the stimulation of the digestive tract by certain poisonous substances, are probably to be interpreted as representing the beginning of protective activity (contraction of the bronchial musculature, or of portions of the digestive tube preparatory to vomiting). They are further noteworthy as associated primarily with the entrances of the great receptive

¹ These reactions may of course represent in part merely the direct effect of a mechanical stimulus upon plain muscle tissue (see American Text-book of Physiology, 1896, 308), or upon its resident motor endings.

² The question whether the afferent neurones of autonomic ganglia have any connection with the higher centres is, as we have already shown, a difficult one. Neurological study has revealed so far merely the passage of a number of medullated afferent fibres through these ganglia on their centripetal course from the epithelium. Since, however, the ganglia are accessible to influences from higher centres, *i. e.*, have efferent connections with the cord, the supposition that they have also some sort of afferent connection does not seem extravagant.

³ Here, as in the case of satiety, certain possible parietal peritoneum sensation, attending increased pressure of the organs and their contents upon the linings of the body wall, may be responsible for the conscious effect.

systems of the body, and as representative of abnormal or injurious conditions.

This brings us to the real reason for the prepossession in favor of correlating sensation with functional stimuli, which is partly a matter of argument that the consciousness of excessive or harmful activity can alone be of value, partly a matter of observation that in such familiar complexes as fatigue, hunger, colic, cardiac oppression, stuffiness, the nausea of indigestion, it is pre-eminently excessive functional activity or the need for such activity which comes to consciousness.

The fact that the functional activity of the organism is closely associated with metabolic change makes a strong case for those who regard the adequate internal sensory stimulus as pre-eminently chemical. The aptness of this doctrine in many of the above mentioned experiences, and especially in such generalized bodily states as faintness, exhilaration, etc., is manifest. At the same time, the probabilities are strong that a certain amount of mechanical stimulation (either muscle contraction, distension, stretching, or pressure upon parietal peritoneum surfaces) enters into the production of such psychoses as cardiac oppression, stuffiness, nausea, satiety, and colic, as well as into the majority of functional activities. Even such apparently refractory cases as the peripheral sensations characteristic of extreme nervous exhaustion and low blood pressure, and usually referred to hypothetical chemical changes affecting circulatory endings or the nervous system generally, may be reduced to mechanical terms, as Sherrington has demonstrated by referring them to the possible relaxation of certain tissues usually kept turgid by an abundant supply of lymph, *e. g.*, the Pacinian corpuscles. Therefore, although Meumann has proposed the chemical processes or products as the appropriate stimuli of internal sensation, and Kröner has posited an indefinite number of organic products as the immediate agents of felt internal changes, we may side if we like with the physiologist Sherrington in the less fanciful belief that the internal sensory stimulation is effected largely by known mechanical agencies,¹ and that such chemical sensations as do occur are probably cases of 'inadequate' stimulation, analogous to the production of visual sensations through the galvanization of the optic nerve.

However this may be, the limits of sensibility may be defined about as follows. The activity of the internal glands, and of the long middle stretches of the digestive tract, are presumably normally non-sensory. Even in the deep tissues for the sensory character of which physiology or neurology offers

¹ Schaefer: *op. cit.*, 971-2.

some warrant, *i. e.*, certain muscle layers (in the stomach, diaphragm, and possibly the heart), certain serous membranes (dura mater, pericardium, pleuræ, peritoneum parietale), certain epithelial surfaces (bladder, stomach, etc.), the appropriate conditions of excitation are probably rare. In both painful and non-painful stimulation spatial summation is presumably important; for both there is undoubtedly a high areal limen. Further, repetition, prolongation, temporal summation, must play a considerable part, especially in pains, whether the stimulus be mechanical or chemical. Whether because of the absence of the differentiated endings and heightened sensitivity peculiar to the cutaneous and higher senses, or to the lack of development of a comparatively frictionless neurone chain (with few synapses) to the higher centres,¹ the liminal values of the sensory endings, and the sensitivity of the viscera to isolated stimulation, are undoubtedly higher and less acute than those of the skin.

3. *Specific energies in internal sensory nerves; the teleological argument.* The question whether the adequate stimuli of the internal organs differ for different endings, *e. g.*, whether there are specific hunger, fatigue or exhilaration stimuli and specialized sets of nerve endings to receive them, whether there is adaptation throughout to a single stimulus mode (mechanical) or whether the effective stimuli are all what is known as 'inadequate' or 'common' in the external pain system, is intimately associated with the problem of specific organic qualities. In the absence of agreement among physiologists, or of definite psychological evidence, we are thrown back upon the teleological argument, which has lately been advanced in favor of specialization. Meumann, for instance, maintains the probability of a great variety of qualities on the basis both of a chemical stimulation hypothesis and the wide variation in the chemical processes and functions of the different tissues,² and of the

¹The speculations of certain writers who suggest that the neural equipment of the viscera represents (at least in its more central portions) an atrophying system, that we have here certain organic functions the stimuli of which were originally conscious, but with the development of higher sensory and functional interests, and the relegation of vegetative functions to subordinate centres, have dropped to the subliminal, while their neural mechanism has undergone a corresponding simplification, seem hardly convincing. Even if these stimuli or functions were originally conscious, they were probably never in relation with a central mechanism or supreme conscious centre, but represent rather originally autonomic and independent functions which are gradually pressing in and at once acquiring a certain influence among conscious processes, and submitting themselves to a certain influence from higher centres.

²Kröner's propaganda for a multitude of chemical stimuli adequate to excite the nervous system as a whole (centrally or peripher-

importance of differentiated qualities if discriminated consciousness of internal conditions is to arise and serve as a warning to the organism. While this sounds not unreasonable, the counter view, that the *sensory* stimuli in the internal organs are essentially alike in character, has a certain cogency of its own. If activity and the need for activity are the primary conditions sensed, this appropriate stimulation might conceivably be mechanical and homologous in all organs, *e. g.*, compression through muscle contraction, or tension and intercellular pressure, varying with vascular dilatation, or with the turgidity of the gland cells in a resting tissue. Further, in so far as Meumann's argument rests upon the need of differentiated qualities as the basis for the sensing and localizing of organic wants, we may suggest that the 'local sign' or individualizing factor of any visceral experience is not of necessity qualitative *sensu stricto*. It may take the form either of an intrinsic peculiarity in the grouping or sequence of the sensations, of an acquired local reference, or of the external associated adjustments in which the internal need finds partial, and reflex or instinctive expression (*e. g.*, the muscle contractions preceding vomiting, evacuation and the like).

The whole problem of specific nerve excitants and qualities comes out especially in the speculations as to the real nature of hunger.¹ Opinion differs as to whether the adequate excitation is diffused and general, operating mainly through the altered composition of the blood, or local and relative to the condition either of the mucosa or muscle coat of the stomach, or of both. Those who are unable to reconcile the conditions of its appearance with their own theories of internal excitation regard it as centrally excited;² the majority can explain its peculiarities only by reference to both peripheral and central sources.³ Those who derive it from contraction of the muscle fibres in the walls of the stomach (Müller, Weber,

ally, and in its external or internal branches), and represented each by its individual conscious quality, stands in defiance not only of teleological argument and scientific 'parsimony', but also of all accepted views of nerve excitability and specialization.

¹For the facts and theories cited see: J. Müller: *op. cit.*, I, 530; E. H. Weber: *op. cit.*, 145; A. Bain: Senses and Intellect, 129; H. Helmholz: *op. cit.*, 48; A. Goldscheider: *Gesammelte Abhandlungen*, 1896, I, 46; Kröner: *op. cit.*, 59; W. Nikolai: Ueber die Entstehung d. Hungergefühls, 1892 (reviewed in *Zeit. f. Psych. u. Phys.*, 1893, V. 358); H. Beaunis: *Sensations internes*, 24-35; Schaefer's Text-book of Physiology, II; C. S. Sherrington: 991-3 and E. H. Starling, 321; W. H. Howell: Text-book of Physiology, 1906, 267-8.

²Z. Oppenheimer: Physiologie des Gefühls, 1899, 36 ff.; E. Becher: Ueber Sensibilität d. inneren Organe, *Zeit. f. Psych. u. Phys.*, 1908, XLIX, 358.

³See Beaunis' discussion.

Bain) are inclined to identify it with the muscle (or pressure) quality proper; those who trace it to the mucosa (Külpe, Goldscheider, Sherrington) recognize the possibility of specific endings, specific stimulus, and sensation quality, though inclined to relate it closely to cutaneous sensation.

The physiological facts, drawn from observations in normal and abnormal cases (fistula, fever, etc.), from X-ray examinations and experiments upon animals (cutting of vagi or sympathetic, introduction of nutriment into the duodenum, or of non-nutritious material into the stomach, œsophagus, etc.), are briefly as follows. The stomach in a fasting or hungry animal is empty, anæmic, and at rest in a state of slight tonic contraction, the mucosa being thrown thereby into folds. The sensation which arises under these conditions is temporarily banished by the introduction of any bulky substance into the stomach, or by pressure from the outside; if normally satisfied, it passes over into the feeling of satiety. Further, if not appeased, hunger may after a time disappear of itself, usually to reappear later in intenser form; or its appearance may be considerably advanced or deferred by alteration in the meal hour and habits of the individual. Lastly, dogs evince signs of appetite with both vagi cut, and with the sympathetic connections intact or severed.¹

Beaunis after a critical consideration of these facts is inclined to suspend judgment and attribute hunger to both central and peripheral causes, the latter to include the condition of the stomach, œsophagus, pharynx and masticatory muscles. Sherrington regards the tension of the mucous lining resulting from local alterations in the blood supply, or the intercellular pressure arising from the engorgement of the cells of the mucosa with digestive granules as all important. The explanation of Goldscheider seems, however, to do most justice to the gnawing, uneasy, fluctuating character of the sensation as usually described. Goldscheider explains it as an irregular pressure sensation analogous to that produced in a finger from which the blood supply has been partially cut off, and in which, owing to the local anæmia, the separate pulsations of the blood are vaguely and unpleasantly sensible. This or some similar use of the fact of anæmia (such as the chemical action on the nerve endings of a diminished or impoverished nerve supply) seems to the writer the most satisfactory; especially since the relief of hunger is always associated with conditions (active peristalsis, introduction of bulky substances, of water, or of

¹Doubt may, however, be expressed as to whether in the latter case the feeling of hunger itself is present, or merely a co-ordinated eating reflex and its accompaniments.

certain irritants, or predigested substances), the immediate effect of which would probably be either local hyperæmia or a general alteration of the consistency of the blood.

While some writers suggest hypothetical products of oxidation in the muscle tissues or blood as the peculiar stimulus of hunger, no organic substance is known which when injected will produce the sensation. It would hardly seem necessary, therefore, after a survey of these facts, to assume a specific hunger apparatus (and quality) beyond the presence of sensory endings in the stomach so situated as to be especially exposed to mechanical or 'common' and 'inadequate' stimulation through drying or intercellular conditions in general. The consideration of hunger, therefore, adds little weight to the doctrine which would make the internal sensory nerves responsible only to differentiated (chemical?) stimuli. Their accessibility to 'inadequate' or 'common' stimulation or their uniform adaptation throughout the viscera to some form of mechanical excitation (compression?) would, for all we can see, be equally satisfactory.¹

As to the biological sanction for the existence of visceral sensations (apart from the question of specific qualities), we must agree with Meumann that bodily feeling undoubtedly performs a function in securing concentration on the pressing organic needs of the moment,² even if, with Becher, we must admit that this function may be in large measure performed by sensations not 'organic' or 'visceral' in the strictest sense.

4. *Origin and differentiation of the organic contribution to emotion.* One of the principal objects in examining the physiological evidence is to determine the possible scientific basis for the conscious activity of some specific organ (heart, liver, kid-

¹ The writer was at first inclined (on the basis of personal observations) to identify the sense quality of hunger as muscular. Laboratory investigations have, however, shown that the quality usually characterized as 'muscular' is by no means peculiar to muscular tissue or contraction but may be obtained by the application of pressure over almost any surface or structure. In view of this fact and of certain others relating the appearance of hunger to the condition of the mucosa, and its absence in disease to pathological changes in the latter, it seems unnecessary to hold to a muscle theory pure and simple, based, as such a one must be, either upon some hypothetical chemical substance, or very doubtfully upon the quite moderate tonic contraction of the muscle coat, since the absence of active peristalsis antecedent to the beginning of digestion is established by modern physiology.

² Even the internal distress of slightly abnormal conditions (such as insufficient or injurious diet, unfavorable climate, etc.), usually cited as a positive disadvantage, may possibly, in the opinion of the writer, operate not unbeneficially in primitive conditions, by inducing a restlessness which may lead to change of habit or habitat, and thus possibly to amelioration of conditions.

ney, or the like) in association with some particular emotion—grief, anger, fear, etc.¹ With the data of physiology and of immediate experience at our command, the direct effect of mental processes upon the great reflexly or semi-reflexly governed organic mechanisms, along with the subsidiary effects upon the glands, capillaries, and unstriated muscle fibres of the skin may be roughly sketched.²

Of these no doubt the larger number appear primarily as changes in the external muscle or cutaneous system, as alterations in the activity or tonic contraction due to increase or decrease in innervation of the large body or respiratory muscles, or of the unstriated muscle layer of the skin (gooseflesh, etc.). Others, representing primarily internal changes (vaso-motor?), may nevertheless come to consciousness only through their effect upon the sensory nerves of the cutaneous or body wall system (as tingling, temperature, shudder, etc.). On the other hand, changes in the great body muscles may have a secondary sensory effect upon the serous linings or viscera, while a certain fraction of the bodily response undoubtedly finds expression in the direct inhibition or reinforcing of the activity of the latter.

In general, mental events, acting now as stimulants, now as depressants, upon this centre and that, may give rise to the following bodily changes and probable sources of sensation. In the respiratory system, to violent expulsion or suspension of the breath, and frequently prolonged contraction of certain of the expiratory muscle groups, thoracic and abdominal, involving compression of the viscera, or pressure upon the serous linings of the two cavities, along with altered conditions of cardiac activity; or to increased capacity or depth of the excursions of the diaphragm, and a resultant quickening of the activity of the affected viscera (thoracic especially), along with various remote effects from the increased rate of oxidation in the tissues, heightening of innervation, etc. In the heart, to inhibitory action, followed by increased dilatation in diastole and pressure on the pericardium; or to violent contraction, increased carotid pressure, choking sensation in the throat, etc. In the circulatory system at large, to constriction (possibly even painful) of the cutaneous arterioles, attended by dilatation in the cortical system and a corresponding rise of pressure on the sensory endings of the dura mater, possibly also by sensory effects due to the rise of pressure in the great arteries; to dila-

¹An ancient doctrine, the modern version of which is perhaps to be ascribed to J. Müller.

²See C. Lange: *Ueber Gemüthsbewegungen*, 1887; A. Mosso: *Fear*; W. James: *op. cit.*, II, 478-9; Th. Ribot: *Psychology of the Emotions*, 1898.

tation, flushing, and changes of temperature in the cutaneous system; or to secondary vaso-motor effects (probably due also to direct secretory reflexes) upon the lachrymal, salivary, urinary, and sweat secretions, along with the sensations not improbably resulting from disturbance of each of these systems.

Further into these hypothetical changes, physical and conscious (and their possible classification as purposive or merely irradiatory phenomena, resulting from casual overflow of stimulation in sensory or motor centres), we need not here go. It is noteworthy, however, that physiological data so far fail to suggest any basis for strongly differentiated reactions, involving entirely different organs in isolation, in the case of different emotions or feelings. As Féré and others have pointed out, bodily effects are classifiable mainly as sthenic and asthenic, as furthering or retarding the vital functions *en masse*. It is, of course, quite possible that though differentiated merely as stimulant, depressant, and possibly suspensory in action, the various affective states in virtue purely of a difference in the intensity of their inhibitory or excitatory powers, may call into activity a different range of organs according to the susceptibility or exposure of the latter, and thus give rise to a conscious differentiation. In general, however, while heart sensations (cardiac oppression) may doubtfully be classed as characteristic of depressing emotions; respiratory (or general?) sensations, of exhilarating; and general innervation sensation, of the intermediate exciting and soothing emotions, the basis for any finer differentiation of the internal response is indecipherable in the present state of our knowledge.

C. CLINICAL AND PATHOLOGICAL EVIDENCE.

From the surgeons and experimenters who antedated the general use of anæsthetics (Haller, Bichat, etc.) has come down the doctrine that the internal tissues are insensitive except in case of disease or inflammation.¹ On the limited significance attaching to an insensitivity based on data so restricted we have already commented. The question might indeed be dismissed for the present on the ground that men such as Helmholtz, Müller, Beaunis, Sherrington and d'Allonnes freely admit the normal presence in consciousness of a variety of sensations from the internal organs. Since, however, the dividing line between internal and external sensation has never been accurately established, the possibility of error or illusion in the identification or observation of the former must be admitted. As a matter of fact, the interpretations which certain

¹Cf. E. A. Schaefer's Textbook of Physiology, Vol. II, pp. 970-71; and W. Nagel, Handbuch der Physiologie des Menschen, III, p. 699.

surgeons and clinicians have placed upon the insensitivity of the internal organs in operation contain important implications not only as to the plausibility of a plurality of organic qualities but further as to the trustworthiness and feasibility of observations on organic sensations in general. A closer scrutiny of the facts and hypotheses of this group of workers seems therefore desirable.

The work of the three surgeons (Lennander, Head, and Mackenzie) which we shall here examine deals exclusively with pain; and, further, with the pain of abnormal or diseased conditions. Indeed, the main problem grappled is just the reconciliation of the occurrence of pain in disease with the (assumed) insensitivity of the viscera in health. If the normal afferent impulses are merely reflex in function, possessing no means of access to the higher centres, if in health the internal tissues are proof against all ordinary mechanical, thermal, electrical or chemical stimuli, what can be the conditions of stimulation, what the nervous mechanism by which in case of disease or inflammation a pain excitation is propagated to the cortex? How explain the development or persistence of a pain mechanism or pathway which functions rarely, perhaps never, in the lifetime of the individual?

Certain physiologists and psychologists¹ seem inclined to find the solution of the riddle in the doctrine of semi- or sub-conscious organic sensation always with us but pushing into the focus of consciousness only when greatly intensified, as pain.² The Swedish surgeon Lennander,³ however, scorns any such subterfuge and cuts the Gordian knot by practically repudiating the possibility of any visceral sensation whatever, in health or disease. The data on which this bold solution of the dilemma is based are the result of an extensive and varied experience with surgical cases in which a local anæsthetic only was used. The observations cited cover the testing of a large number of the abdominal viscera, in a state both of health and disease, of rest and of violent contraction. No sensitivity was in any case encountered, *unless* the stimuli employed affected the parietal peritoneum either directly or indirectly. The

¹M. Foster: *Textbook of Physiology*, IV, 284; and G. T. Ladd: *Psychology Descriptive and Explanatory*, pp. 175-6. Ladd, however, is not immediately concerned with the problem of pain, but rather with the 'feeling' function of the sympathetic. See also R. Lagerborg: *Das Gefühlsproblem*, for the theory that only change is sensed.

²Such an hypothesis assumes, of course, that conditions requisite for the production of pain are inherent in any sensory mechanism, ignores the need of a specific set of pain nerves, or a special pain pathway.

³K. G. Lennander: *Beobachtungen über die Sensibilität in der Bauchhöhle*, *Mitteilungen aus den Grenzgebieten der Medizin und Chirurgie*, 1902, X, p. 38. See also references in Nagel, *op. cit.*, p. 700.

latter responds with pain to light contact or palpation as well as to stretching, and one case at least is noted in which the patient was able roughly to locate the sensation thus produced as upon the right. Neither pain, touch, nor temperature sensations, Lennander therefore concludes, are ever initiated in the nervous tissue of the viscera proper: the sympathetic fibres which supply the internal organs are vegetative or reflex in function merely.¹ Direct stimulation of the cerebro-spinal fibres in non-visceral tissues is requisite to the production of sensation. The pain sensations of operation or inflammation which are usually attributed to the internal organs arise really from the accidental stretching or infection of the parietal peritoneum, pleura, or diaphragm (through the excessive peristaltic action in the adherent viscera, or the spread of noxious chemical products from inflamed and closely associated tissues), and the resulting stimulation of nerve fibres (intercostal, lumbar or sacral, etc.) running in or immediately beneath the structures mentioned. The findings of other authorities² are believed by Lennander to be in general reconcilable with this hypothesis. Many surgeons have noted the sensitivity of the parietal peritoneum, while most assertions of the sensitivity of the viscera in disease are matters of inference merely. The classic citation of the insensitivity of the parietal peritoneum rests merely upon a discredited eighteenth century experiment of Haller's upon animals, in which the structureless and nerveless character of the peritoneum is assumed from the start and no attempt made to keep the nerve connections intact in preparing for the experiment.

In criticism of Lennander's sweeping rejection of the possibility of any pain, pressure or temperature sensation from the viscera proper, Meumann in a recent article has raised the following objections: the limitation of the observations to experimentation with artificial and inadequate stimuli, and the unfavorability of the conditions to detailed and accurate observations, *i. e.*, the improbability that under the excitement of operation any sensation short of severe pain could have made its way to the perception of the subject.³ With regard to the inadequacy of the stimulation we have already raised a

¹*Op. cit.*, p. 104.

²*Op. cit.*, pp. 50 ff. For corroboratory evidence, see also J. F. Mitchell, Local Anæsthesia and General Surgery, *Journal of the American Medical Association*, XLIX, 3, 1907, p. 198.

³E. Meumann: Zur Frage der Sensibilität der inneren Organe, *Archiv für d. gesam. Psychologie*, IX, 1907, p. 26.

He also places the weight of certain *a priori* arguments, and of his own observations and introspections, in favor of the probability of a varied continuum of sensations from the internal organs, as already noted.

further point. The rôle of summation in internal excitation, recognized by the physiologists but totally ignored in the inferences of Lennander, may in part explain why such stimuli as stretching, or intensive contraction of the muscular wall of the alimentary canal, which we have every reason to think represents a normal source of sensation or stimulation, should be as ineffective as cutting, contact, and thermal applications.

In attempting to evaluate Lennander's conclusions, it may be useful to point out the two sources of his bias in favor of the total insensitivity of the viscera: the insensitivity in surgical operations to pain of all tissues (so far as tested) except those immediately associated with the body wall and diaphragm; and a prepossession in favor of the co-ordination of sensory function with cerebro-spinal nerves. With regard to the latter, it is noteworthy that in acknowledging its influence on his choice of the subserosa (which is innervated from spinal nerves) as the sensory tissue of the abdomen, he apparently ignores the cerebro-spinal fibres which Langley and others have traced into the viscera along sympathetic pathways. As to his results in general, regret must be expressed that more careful records of the apparent localization of the pain following the stimulation of different parts of the peritoneum was not kept. Finally, we may again suggest that even though much of the pain of disease, and probably the greater part of that incident to surgical operation, arises in the fashion prescribed by Lennander, this admission leaves the problem of the actual seat of origin of the various internally referred experiences of normal life practically untouched.

The position of Mackenzie is only in small measure less extreme than that of Lennander. According to the former, all internal reference of sensation is an illusion, an error of judgment; the body wall (muscle, skin, and subserosa) alone is sensitive. The afferent pathways of the viscera do not extend to the cortex. In so-called visceral pain, the nerve impulses may indeed be initiated in afferent fibrils of the unstriated muscles of the internal organs (never in mucosa or serosa even in case of disease or inflammation), but they attain to consciousness only by transference to cerebro-spinal pathways and centres belonging properly to the body wall. This conclusion is based in part upon the static character of the pain referred to certain organs known continually to undergo changes of position, such as the heart and stomach, in part upon the discrepancy found to exist between the limits of the spontaneous pain of disease (as defined by palpation in diagnosis) and the limits of the diseased organ or tissue itself as revealed in operation. In view of these facts and the marked sensitivity or hyperalgesia (as tested by pinching between the fingers) of

the body wall over the affected organ or thereabouts, he assumes that 'visceral' pain is mediated by irradiation from afferent neurones of the viscera to sensory neurones supplying fibres to the skin, muscles or subserosa¹ from the same segment of the cord, and is accordingly referred to the same general region of distribution as the latter.² The superficial tenderness of disease is merely another phase of this irradiatory action and is indicative of the hyperexcitability to which the neurones of the external system have been raised by continual irritation from visceral fibres.³ That is, Mackenzie reconciles the insensitivity of the viscera during surgical manipulation with the apparent sensitivity of diseased organs in diagnostic handling by declaring that in the latter instance only somatic (body wall) nerves are affected. Afferent impulses capable of terminating in pain can apparently be excited in the viscera by no artificial means unless it be stretching. Their adequate stimulus is prolonged or excessive contraction.⁴ The sensitivity of the serous membrane is denied on the basis both of clinical cases and of the poverty of nerve endings in that tissue, a dictum apparently widely at variance with that of Lennander. Since, however, in the second article quoted, Mackenzie admits the sensitivity of the subserosa along with the skin and muscle of the body wall, his earlier statement is not necessarily unreconcilable with Lennander's insistence on the pain function of the parietal peritoneum.

On the purely afferent and non-sensory function of the sympathetic fibres Mackenzie is in his way as dogmatic as Lennander. Pain is a function of cerebro-spinal nerves only. It is always 'somatic', never 'splanchnic', as its reference in any given case to the general area of distribution of the cerebro-spinal nerves which would conceivably be affected through irradiation bears witness. Its internal reference, when this

¹ Mackenzie: Meaning and Mechanism of Visceral Pain, *Brit. Med. Jour.*, I, 1906, pp. 1449-54, 1523-28.

² This explanation of the nature and mechanism of 'referred' or transposed pain is really a development of the irradiation hypothesis for 'sympathetic' pain put forward in the rough by J. Müller (*Elements of Physiology*, tr. by Baly, 1837, Vol. I, p. 723), and first definitely applied by J. Ross (*The Segmental Distribution of Sensory Disorders*, *Brain*, X, 1887, p. 333).

³ It is interesting to note in this connection that the fact of hyperalgesia is apparently reconcilable only with the theory which accords a common peripheral apparatus to touch (or temperature) and pain, accounting for the latter by the hypothesis of a secondary high resistance conduction path in the gray matter of the cord. The doctrine of specific pain endings with high limen of stimulation would apparently offer no basis for this lowered sensitivity.

⁴ *Brain*, XXV, 1902, p. 368.

takes place, is essentially illusory.¹ The adaptive or purposive nature of this device (*i. e.*, the transfer to body neurones and the substitution of body wall hyperalgesia or pain for visceral pain) he argues from the fact that the hardening of a portion of the body wall, reflexly effected in consequence, undoubtedly serves as a protection to the affected tissues situated actually or approximately beneath.²

Such a theory, denying as it does the existence of any private pathways from viscera to cortex, with central stations of their own, would, if accepted, cut away the ground from the hypothesis of specific organic qualities, hunger, nausea, suffocation and the like. Even though the transfer of non-painful as well as painful impulses were conceded these must, according to accepted theories, appear in the qualitative guise peculiar to the borrowed paths or neurones.³ Several points may, however, be raised against the unconditional acceptance of Mackenzie's line of argument. First, in denying sensory functions to the sympathetic on the score of the fewness of its fibres in proportion to the bulk of the viscera, and the other and varied functions which these must subserve in the vegetative economy of the organism, he ignores both the possibilities of intensification through spatial summation provided by the sympathetic, and the presence throughout the system of cerebro-spinal fibres. Secondly, the peculiarities of local reference adduced in support of his conclusions are in the main handled on the basis of a psychology of space too naïve and ambiguous to be convincing. For example, in proceeding

¹ A curious instance of an illusion which represents the objective if not the immediate subjective truth. The seat of the disturbance is pretty correctly sensed, but the significance of the route by which it reaches the cortex is ignored. It may, moreover, be suggested that the secondary pain path in the cord which Mackenzie evidently assumes may just as well be conceived of as belonging to the internal as the external system, and it may be regarded as only more or less of an accident that the local signs of the external system customarily adhere to its stimulation. In this case the insistence on the illusion of internal reference loses much of its force.

² The displacement of the viscera from their original segmental position in the course of mammalian development is called upon to account for the occasional discrepancy between the position of the diseased organ and the localization of the pain or the section of the wall contracted.

³ The query might be raised in this connection as to why leakage to temperature and pressure as well as pain neurones does not take place in the cord, *i. e.*, why visceral disturbance is not sometimes sensed as heat, cold, or temperature. Mackenzie would, however, probably answer that every sensory neurone has a high resistance gray matter conduction path correlated with pain, and that impulses intensive enough to escape from visceral to body wall neurones are also intensive enough to effect the passage of this path, to the prejudice or swamping of the other possible sensations.

from the fact that the abnormal position of an organ is not correctly sensed to the conclusion that the seat of all sensation must therefore be in the stationary body wall, he ignores the customary mechanism of localization, *via* associations, visual, motor or the like, based upon the accumulated data of experience, and holding good for normal or typical cases only. The localization of pain in a constant position with reference to the body wall, though the actual situs of the organ excited may have altered, is a phenomenon resting conceivably upon the same basis as the reference to an amputated limb of sensations arising from the excitation of the nerves of the stump. Further, in the case either of stationary or moving organs a certain amount of vagueness or inaccuracy must always be allowed for in view of the peculiar conditions and the lack of incentive to the establishment of exact processes of localization in the viscera.¹ Mackenzie, however, habitually speaks of space perception in terms of immediate intuition. Again, the reference of internal sensation toward the anterior body wall, which is indeed commonly noted,² and which might appear to support Mackenzie's thesis, may be often merely a matter of the attraction of the sensation to be localized outward, toward visualizable or familiar boundaries, rather than inward toward an unexplored third dimension. Moreover, the fact of body wall hyperalgesia or pain is in itself no argument against the simultaneous presence of true visceral sensation, as indeed Head himself virtually admits. Lastly, no positive evidence against the direct conduction of sensory impulses to the cortex from the viscera by visceral neurones is adduced by Mackenzie. This point is merely inferred from the assumed incapacity of the sympathetic for pain.

Head,³ in his article on visceral disease, occupies a less radical position than either Lennander or Mackenzie, admitting as he does that the viscera are veritably sensitive, mucous, muscular, and serous surfaces alike. Pain both originates and may be felt therein without involving an 'error of judgment'.

¹ This same criticism does not, of course, apply to Mackenzie's citation of the decided regional separation of reference in the pain from the large and small intestines (*op. cit.*). If his statement that pain from the large intestine is confined to the region below the umbilical area, while pain from the small intestine is customarily referred higher, is sustained by the observations of others, some extra-visceral explanation of the severe pain of visceral disease must evidently be sought, whether in terms of his own system or of that of Lennander or Head.

² This peculiarity has, as a matter of fact, been noted by both Helmholtz (Tatsachen in der Wahrnehmung, p. 48) and Meumann (*op. cit.*, p. 52).

³ H. Head: On Disturbances of Sensation with Especial Reference to the Pain of Visceral Disease, *Brain*, 1893, XVI, 1-333.

Such pain is, however, of the dull, diffuse, vaguely localized variety, akin in every way to the 'protopathic' type of cutaneous sensation which Head in his article on the injury of the nerves of the arm has separated out from the sharply defined and located 'epicritic' sensitivity of the same region. For this dull internally referred sensation of the viscera either sympathetic endings or cerebro-spinal fibres terminating in Pacini corpuscles are responsible,¹ and in its mediation presumably only visceral neurones are concerned. The great bulk of visceral pain is, however, of the sharp, stabbing, clearly defined variety, and is felt in the cutaneous region innervated from that segment of the central system from which the nerve supply of the organ affected is also derived, owing to the transfer of the afferent impulse from visceral to cutaneous neurones in the cord. In support of this conclusion, which in itself, of course, represents little new, he cites (and here lies his importance) a tremendous system of evidence drawn from detailed mapping of the areas both of tenderness (hyperalgesia) and of severe pain attending affections of the various viscera, together with similar observations upon the skin areas affected in herpes zoster at different levels of the cord. The observations for both herpes zoster and hyperalgesia show irradiation in non-overlapping bands around the body; peritoneal and serous affections alone constitute an exception to the rule. Further, the points or areas of severe pain lie usually in the corresponding hyperalgesic regions, and frequently at some distance from the tissue diseased.²

In this theory, as in the doctrine of Mackenzie, the irradiation of nerve impulses posited offers no especial difficulties. Its operation would indeed be essentially similar to that of the mechanism assumed in the ordinary theory of a gray matter conduction path for the pain of the external system. The difference is mainly that where the latter assumes for any peripheral neurone a direct route for non-painful impulses, an indirect one for pain, the hypothesis of Head practically maintains two pain paths to the cortex, a primary private path, and a secondary one borrowed from the external or cutaneous sys-

¹ The Afferent System from a New Aspect, *Brain*, 1905, XXVIII, 99-113.

² The facts that the areas mapped are not appreciably overlapping, and that gaps in cutaneous reference correspond precisely to the regions supplied by the brachial and lumbar sections of the cord, which Langley has shown send no fibres to the viscera, are cited in favor of the hypothesis that the irradiation takes place in the *cord* and not in the spinal roots, each of which may be derived from several adjacent segments of the cord and which represent irregular and overlapping peripheral fields.

tem.¹ The external secondary path theory assumes either that the centripetal impulse expends itself in forcing the high resistance path and in the production of pain, or that the excitation travelling along the primary pathway reaches consciousness also, and is sensed in its appropriate terms, although frequently swamped by the pain component approaching along the secondary path. This second alternative is evidently that adopted by Head for visceral sensation. He does not actually deny the existence of a true visceral pain simultaneously present and parallel with the sharp 'referred' skin pain, but this if present blends with the latter, is *felt* in the skin. That is, there is not only a physical transference of visceral impulses, and a corresponding projection, but also a psychical misreference of true visceral pain.² This peculiar state of affairs is, however, quite adequately explained by Head as analogous to the allocheiria which arises in the external system under certain abnormal conditions entailing reduced sensitivity of certain regions, and which is definable as the reference of a sensation to a more sensitive associated area (adjacent or symmetrical). The terms in which Head phrases the application of this principle to visceral pain are somewhat obscure, but the process itself seems readily explicable on the ground that the cutaneous nerve impulse or corresponding cortical end process commands a more definitely organized body of assimilating and localizing associates, and, further, possesses a more efficient directive power over these associates (in virtue perhaps of its intrinsic energy or dynamic intensity), than the feebler nerve processes in the organic channels proper. Hence in cases of relatively intense visceral excitation with irradiation into cerebro-spinal channels, the perceptive associates controlled by cutaneous neurone processes swamp those of the less vigorous organic components which gave them origin. In the words of Head, the 'diffusion area' is accepted by consciousness by an 'error of judgment'.

If we grant, as we must, the essential reasonableness of Head's hypothesis, the desirability of harmonizing his observations with those of Lennander at once arises. Unfortunately, however, the two sets of data are taken from too widely different points of view to be readily comparable. In the absence among Lennander's observations of any detailed correlation of

¹ This peculiarity apparently arises from the fact that Head favors specific pain nerves rather than a secondary path theory for both the external and the internal system (*op. cit.*).

² That is, Head's statement seems to indicate that it is the corresponding localizing associations or cortical processes rather than the visceral pain itself which fail to rise above the limen of consciousness when accompanied by referred pain. *Cf.* Disturbances of Sensation, *Brain*, 1893, XVI, 124-6.

the objective and subjective sites of disturbance, *i. e.*, of the precise location of the portion of the peritoneum affected and the localization of the accompanying pain (by the patient), the weight of authority must rest with the elaborately systematized and coherent results of Head. The likelihood that if Lennander's denial of the sensory functions (direct and indirect) of the sympathetic system were accepted, the subserous parietal neurones could be substituted for visceral proper as the source of irradiation to cutaneous neurones, without doing violence to the system of facts accumulated by Head seems slight. If Head's referred pain of the hyper-sensitive bands were to be ascribed to stimulation of the intercostal or lumbar fibres running in or beneath the parietal peritoneum (to supply the body wall) and external reference of the corresponding excitation through either irradiation, or peripheral projection, it would be difficult to explain such facts as the reference of visceral pain higher or lower according as the cardiac or pyloric end of the stomach is affected, since presumably in either case the entire gastric connection would be concerned. This difference in reference might of course find a basis (in terms of the theory of Lennander) in the probability that affections of the cardiac end of the stomach involve the peritoneal connections with the diaphragm, affections of the pyloric end, the lower and dorsal mesenteric attachments of the duodenum. Similarly, Mackenzie's instance of the higher and lower reference of pain according as it originates in the small or large intestine might be explained by recourse to sites of the corresponding peritoneal connections—mesenteric in the former case, lower caecal or sigmoid flexure attachments in the latter. So far as the bandlike hyperalgesic areas are concerned, however, these according to Head could never be assigned to peritoneal stimulation since the pain arising from the parietal peritoneum (*e. g.*, in cases of inflammation) is never referred (*i. e.*, never transferred through irradiation to cutaneous neurones), and is irregular, not bandlike, in its manifestation; that is, such diffusion of sensation as does occur is a matter not of irradiation but of peripheral projection of sensations resulting from the stimulation of fibres somewhere on their centripetal course. It seems on the whole, then, probable that while Lennander's explanation is valid for certain active and gripping pains such as those of colic, Head's holds for certain other semi-pathological hyperalgesic or referred pains. At the same time the possibility of genuine resident pain or normal sensation in the viscera is not disposed of.

This brings us at once to the question of the bearing of the hypotheses of the pathologists upon the problem of the localization and sensing of normal sensation (if this may be

granted to exist). What explanation, for instance, does each system make possible of the off-hand local reference of un-painful as well as painful organic sensation, what possibilities of illusion in regional localization as well as in inward reference does each reveal?

The popular notion of localization is of course that the seat of hunger, nausea, or internal pain is either immediately and intuitively sensed, or may be ascertained by means of exploratory pressure from without. The important rôle, however, which such suggestion, and an atomical or physical knowledge may here play (see for instance the wide divergences in the localization of hunger in the case of the educated and the uneducated reported by Beaunis) and the uncertainty and instability in the mechanism of localization thereby indicated would seem too great to warrant the application of any nativistic doctrine. With regard to the second alternative, localization by means of palpation is indeed abstractly conceivable, if external pressure be admitted as effective in either setting up, diminishing, enhancing or putting an end to the particular sensations concerned, as immediate experience would seem to affirm, and as indeed Meumann has assumed, without any apparent sense of the contradiction involved with his principle that functional changes alone are the adequate stimuli of sensation. Or, localization might be empirically effected by evoking certain definitely localized muscle or skin sensations which in previous experience have become so closely associated with or assimilated to the internal sensations in question as to represent their local sign, as Helmholtz suggests.¹ In either case, however, we find ourselves immediately involved in the necessity of reconciling the setting up of said alterations in internal sensation and the formation of associative local signs out of external sense material, with the pathologists' doctrine of the insensitivity of the viscera to all mechanical stimulation.

Irrespective of any theoretical limitation of the sensitivity of the viscera, the following possibilities may be suggested. First, while there are indications that pressure does not represent the adequate *pain* stimulus of the viscera, it may nevertheless excite certain of their nerve endings to a sensible if feeble and non-painful action,² as it undoubtedly does those of the parietal peritoneum. Apart, however, from this possibility of direct action, it seems reasonable to assume, whatever theory of the extent of the sensory and non-sensory tissues we

¹ *Op. cit.*, pp., 47-9.

² If as Sherrington maintains (see preceding section) the adequate internal stimuli are largely mechanical (in the form of compression, not contact) there is a bare possibility that in certain cases pressure from without may be feebly if not painfully effective.

may entertain, that such mechanical stimulation affects certain of the *afferent* endings of the viscera, and may thus reflexly, under favorable conditions, through the resulting changes in visceral muscles, evoke sensations. Even more probable is it that through the displacement of gaseous or fluid contents external pressure may produce alterations in visceral distension, and thus give rise to sensation either directly through the stretching of afferent visceral fibres or increased parietal pressure, or indirectly through the compression of the resident endings, or the stretching of subserosal parietal nerves, attendant upon reflexly increased visceral activity. Secondly, with regard to localization through associated sensations or movements. It is, for example, possible that the discharge of the respiratory function may in certain cases be effective in altering sensation, either directly and mechanically through displacement and pressure (in some such way as that suggested above), or indirectly and remotely through the metabolic changes which it induces in lung and other tissues. The external or kinæsthetic sensations thus associated to certain of the internal sensations may come to act as the 'local sign' of the latter and exert a certain directive power over their localization even when arising from different causes. Thus intestinal pain, nausea, and hunger may conceivably get their general reference from the external sensations representative of diaphragm contraction or abdominal wall distension or contraction; the feelings of stiffness or exhilaration their thoracic or cephalic reference through association with chest muscle contractions, or with the constrictions or relaxations of the nasal passages and respiratory entrances. The possibility that the sensations thus associated may represent conditions standing not at all in causal relations, *e. g.*, in the association of sensations due ultimately to general circulatory changes with respiratory movements, of course arises. Further, even where a direct causal connection exists there may be a considerable discrepancy between the actual seat or origin of the sensation and the locality indicated by the external localizing movement. These points come out more strikingly when the localization of pain is examined from the point of view of each of the theories under discussion.

Take, for instance, the theory of Lennander that the peritoneum parietale, pleuræ, etc., are alone sensitive. What becomes of the apparent spatiality of organic sensation, of the possibility of determining its seat in the organism by external palpation? In the first place, the so-called massiveness, or voluminousness, the triple dimensionality of organic sensation, is reduced to a hollow mockery. Further, though the parietal sheet of subserous tissue may be directly sensible to pres-

sure and though every portion of this sheet accessible to such pressure from the outside might have its own local sign¹, yet the portion accessible, also, to stimulation from the viscera must be exceedingly small. Indeed, in the abdomen if not in the thorax it must be limited to precisely those tracts of the posterior and upper walls which can have no local sign so associated to them. Localization toward the front wall of the abdomen must then represent an illusory reference, to be explained either as representative of some such central irradiation and segmental reference as Head has figured in his theory, as the result of the peripheral projection of sensations resulting from stimulation (in the rear wall) of the trunks of intercostal and lumbar nerves, the endings of which, distributed mainly to the front of the body wall, lend their corresponding local sign to the resulting sensation, or in one of ways suggested in the preceding paragraph. In the latter case, the throwing forward may be merely a matter of association with the sensible activity of abdominal and thoracic muscles or diaphragm in respiration, with the pull of diaphragm contraction upon the anterior wall, or the increased pressure of the body against the clothing during inspiration. A basis for the formation of such associations is further afforded by the fact that the pain from the drag of the stomach on its peritoneal connections would conceivably be lightened by lowering the diaphragm, renewed again when it lifted, while in the case of painful pressures upon the peritoneum the opposite would hold. In any case, however, within the theory of Lennander only the most general reference of internal sensation would be possible. Correlation with the precise organ active in its origin would be little short of a miracle.²

For Mackenzie, the localization of internal sensation is simple enough. It is felt always in the body wall, in accordance with the principle of irradiation from splanchnic neurones and peripheral projection, each internal tissue having a definite correlation with some patch or portion of the external body wall. For him, also, exploratory pressure produces a sensory

¹ As a matter of fact Lennander leaves us very much in doubt as to whether he regards pain as the result of the stretching (or inadequate stimulation) of parietal nerves running to supply the muscles and skin, or whether he recognizes the presence of *bona fide* sensory endings sensitive to compression or chemical excitation under the epithelial plates of the peritoneal linings. Unfortunately, neurologists can as yet give us no precise information on such endings.

² In many of the possibilities suggested, however, to call the misreference in which the localization consists pure illusion would be the merest quibble, since the seat of the main physiological disturbance, if not of the immediate sensory excitation, would roughly coincide with the region of reference.

excitation in the somatic endings only, thereby reinforcing the local sign of the centripetal neurones already excited by internal irradiatory processes. In no case is localization trustworthy in any detail. Further, for Mackenzie as for Lennander, the third dimension is an illusion: the distinction between internally and externally initiated sensation is fairly blotted out.

For Head, the above likewise holds true, with, however, certain qualifications, since, according to him, the duller, weaker sensations of pain are actually localized in the third dimension, though somewhat vaguely. With regard to the possibility of applying his principle of referred pain to the localization of faint or unpainful sensations, an expedient suggested by Meumann, it must be noted here that Head himself does not claim that the localization, such as it is, of dull visceral sensation (for him, always pain) is determined by the same law as that of the sharp referred pain arising from the same endings. In dull pain, the excitation is by hypothesis too weak to effect irradiation; and further, a stronger excitation accompanied by sharp referred pain may conceivably never have been initiated in that particular tissue, thus precluding the formation of association with any somatic region. It is indeed difficult, if not impossible (without abandoning the principle of the insensitivity to mechanical stimulation of the internal organs, or modifying it in some such way as we have suggested), to conceive of any mechanism by which even vague localization of the duller phases of visceral sensation could be set up in experience. Head's own position in the matter seems to resolve itself into an intuitive or nativistic theory of organic (and tactual) space. Although in one passage he expressly states that localization is dependent upon association, his treatment of the concept of localization (in another connection) belies his words. He uses, for instance, the fact that at a certain stage in the regeneration of the fibres in an injured nerve trunk diffuse, indefinite reference of sensation alone occurs, as evidence for the classification of sensory nerves into a protopathic and epicritic set, representing different grades of localizability and possessing different rates of regeneration. This would seem to argue a failure to recognize the complex nature of localization, and the necessity for the gradual reinstatement of the processes disturbed by abnormal conditions before accurate reference can again arise. Much the same naïve attitude toward the psychology of localization and reference is apparent in the writings of Mackenzie, as we have already pointed out.

In summary, we may say that so far as the accuracy of regional reference of *pain* is concerned, it is for Head and

Mackenzie, and possibly also for Lennander, only a happy accident that the region of reference and the underlying seat of origin are in some measure and in certain cases coincident or adjacent. Further, with regard to the possibilities of accurate localization of unpainful sensation (if, indeed, this may be granted to exist) the above theories taken strictly offer little warrant. Even upon a more liberal sensory doctrine either of the tissues sensitive or of the adequacy of artificial mechanical stimuli, the probability is strong that localization (especially in the thoracic regions, where the application of direct mechanical stimuli is even more dubious than in the abdominal) means merely association with the local signs furnished by movements which, while often concomitant, are dubiously causal or relevant. It may indeed be that while almost every organic feeling is capable of an apparently definite local reference, such local reference most frequently is a matter of suggestion or inference merely, and is pure illusion so far as the actual position of the nerve endings stimulated is concerned. Again, with regard to internal reference and the third dimension, the insistence of Head and Mackenzie upon the actual external status of many pains usually regarded as internal suggests the probability that among unpainful as painful sensations many commonly rated as internal or visceral may actually originate somewhere in the external system; that no universally valid criterion of external and internal exists; and, lastly, that the separation of organic and external sensation in investigation is hardly practicable.

While the facts and theories of the pathologists, therefore, help us only a very little way in the study of the possible sources and kinds of organic sensation, they are valuable in demonstrating the need of a critical examination of all rough and ready modes of localization or identification of organic qualities, of the clues by which such localization is effected, and their relative validity. It is, moreover, to be hoped that with the extension of the use of local anaesthetics a growing body of available data bearing upon the localization of pain will supplement the introspective and experimental results obtainable under normal conditions.

EXPERIMENTAL

Our object here, as already stated, was to investigate the richness or poverty of the organic gamut; to determine the traits by which organic is differentiated from ordinary sensation; the possibility of singling out and localizing the organic qualities under the play of attention; and, lastly, to devise a fitting terminology for whatever qualitative strains might be found to characterize the different feeling attitudes, emotions, etc. The

classic difficulties in the way of such a scheme have been already cited; the impossibility of isolated stimulation, shortcomings in the way of memory images and other aids to attentive examination and description, and the inaccessibility in laboratory research of the major emotional and vegetative complexes in which organic sensations presumably play their most striking part. Yet the resources of the laboratory are worth more careful examination. Certain comparatively simple or contracted feeling aspects are there at our command: surprise, expectation, recognition or familiarity, alarm, doubt, amusement, certainty. Further, various *Mitempfindungen* or minor organic reverberations are attendant upon simple sensory stimulations accessible, *e. g.*, in the bodily effects of certain tastes, odors, noises, and the like. In such compounds the occasional emergence of an individual organic quality through accidental changes, differences of intensity, etc., is not impossible. Further, by fractionating the observations so as to fix the attention now upon one part of the body, now upon another, and by facilitating description through furnishing the observer with an extended and standardized list of adjectives, it seemed probable that certain verbal clues and associations could be established by means of which various casual experiences such as hunger, fright, drowsiness, nausea, embarrassment, disappointment, regret, and other semi-emotional complexes might later be laid open to analysis and description.

Organic Attitudes. First of all, we devised a set of simple experiments with the Jastrow drop apparatus and a number of series of inkblot figures, names of well-known men, colors, and numerals (with a certain number of blanks interspersed in the series), so arranged as to provide the appropriate conditions for such mental reactions or attitudes as the imaginative, the recollective, expectancy, surprise, and recognition.

These preliminary experiments were pretty uniformly unsuccessful. The four observers tested failed to report any organic factors, beyond various externalized kinæsthetic strains and relaxations, and alterations in respiration, varying little for the different types of experiences. It was evident either that the bodily attitude of active attention and release therefrom is in laboratory experiments of this type so prominent as to swamp any possible specific organic characteristics of the several attitudes, or that some special development of the technique of observation upon physiological sensations was necessary. We, therefore, abandoned for the time the use of reactions to these comparatively complex stimulus situations, and turned to the study of the simpler, more striking and

varied, and hence more readily describable physical reactions to simple sense stimuli of decided affective value.

Organic Reverberations. A number of tastes and odors were tested for their physiological effectiveness, and the following selected: quinine and sugar solutions, vinegar, lemon, sarsaparilla, laudanum, camphor, mace, ammonia, carbon bi-sulphide, listerine, castor oil, gasoline, asafoetida, ginger. These were submitted to the observer for periods of from five to twenty seconds (at considerable intervals), with the instruction to give himself up to the experience of the moment (*not* to the cognition of the stimulus), to get all the pleasantness or unpleasantness possible out of it, and then to report upon any concomitant organic reverberations, diffused or specific, superficial or apparently internal and deep-seated.

In general, all four observers reported with unpleasant stimuli a feeling of revulsion, traceable to the automatic contraction of the muscles of the mouth, throat, nasal or respiratory passages, and sometimes grading into a feeling of nausea. With pleasant stimulation, either a feeling of relaxation, general or localized in the muscles of the face, chest, or limbs; or a 'glow' felt in the head or referred vaguely to the respiratory apparatus, the activity of which seemed always appreciably involved. Sensations of nausea were referred usually four to twelve inches below the larynx, sometimes to the base of the tongue, and described by all observers as wavelike, muscular, uneasy. Pricking sensations on the tongue, in the nasal passages, or proceeding apparently from the salivary glands, were recorded following stimulation from vinegar, lemon, or ginger, or the whiffing of ammonia. In spite, however, of considerable variety and difference in reference (the stomach, œsophagus, respiratory passages, pharynx, salivary glands, etc., were all apparently at one time or another affected) there seemed to be no necessity for referring in description to any specific quality other than the familiar external categories, unless the mention of 'pricking', which seemed neither pain nor pressure precisely, be excepted.

Organic Mitempfindungen. A third set of experiments had for its object the study of certain borderline phenomena (not visceral, but presumably subcutaneous and distinguishable from pressure, contact, or ordinary muscle sensation), such as tingling, the 'creeping' or gooseflesh sensations, etc. Rasping and harsh auditory stimuli and rough textures were used here. For the sake of contrast a number of pleasing tones or chords were introduced into the series, and their organic accompaniments duly noted. A vocabulary of descriptive terms (mostly, it must be admitted, characterizations of merely temporal or spatial peculiarities), such as tingling, pricking, stinging,

thrilly, aching, glowing, dull, sharp, massive, delicate, vague, creeping, and the like, were, after a few observations, supplied to the observer, and their significance later agreed upon. A very shrill whistle, a bowed M_1 fork, cymbals, discords, and a major triad on the König tuning forks were used.

While a considerable variety of organic reactions was thus secured, the introspections again failed to show the presence of any peculiar organic qualities. Among the mass of muscle contractions noted and localized in body wall, limbs, ear, or head region, visceral sensations proper were mentioned only twice, and then doubtfully, as the apparent concomitant of contraction of the abdominal wall muscles. Unpleasantness was sensed mainly as a checking or obstruction of respiration, a general muscular recoil or revulsion, or a positive (localized) pain, *e. g.*, in the ear. Pleasantness was again referred vaguely to the chest or respiratory region. Tingling or waves of shivering, 'creepy' sensations were frequently noted, but not further analyzed or qualified, and hardly internally referred or differentiated from cutaneous sensations.

By this time, then, it was pretty evident either that visceral sensations are lacking in other than strongly toned emotional complexes, or that they are far less easily discriminable from the ordinary external qualities than we had so far assumed. A series of casual introspections on a wide range of spontaneous organic complexes seemed to favor the latter conclusion. Accordingly, in a fourth set of experiments (still more or less crude and exploratory) we set out to work systematically from the known to the unknown, running the observer through a typical series of external sensations—pressure, pain, muscle, etc., and their simple variations—which should then serve as standards of comparison in dealing with the sensations following similar stimulation of the accessible mucosa (*i. e.*, of the tongue, and throat, œsophagus and stomach). Special attention was to be paid to the possible appearance of diverse kinds of cutaneous or subcutaneous and muscle pain; to the comparison of the effects of heat and cold upon mucosa and epidermis; to the analysis of itch, ache, tingle, smart, burn, and other of the simpler external complexes, with a view to the discovery of some new specific element (prick or tingle?) other than the certified pain and pressure qualities, representative, perhaps, of a subcutaneous or circulatory contribution, hence likely to afford a clue to deeper visceral sensations.

Comparison of the Direct Effects of External and Internal Stimulation. Experiments on heat-pain were carried through as follows. Several small areas on the forehead and arm were tested with heated temperature cylinders, the pointed and blunted ends of which were alternately used in order that in

the latter case the appropriate conditions for the stimulation of both warm and cold spots, *i. e.*, for Alrutz' 'heat' fusion, might be present. The stimulus was applied from three to five seconds, allowing considerable intervals for recovery from fatigue. The following is a typical set of observations on the arm with the blunt end of the cylinder.

39° C. *a.* Warm; a little flash of heat toward end.

b. Heat at once, a prickly sharp point, not areal as when merely warm.

41° Warm, then suddenly hot, then warm again.

43° Heat at once, flickers, warmth between.

45° More like heat; never constant.

47° Hot, then pain. Heat flickered, warmth between, pain only with first flash of heat.

51° Heat, changes to pain, but not piercing.

From such observations as these, and further questioning, the fact came out to our surprise that the experience known as 'heat' to our observers is very slightly suggestive of a fusion of warmth and cold. The description of heat as a *point* without the *areal* feeling common to warm and cold spot stimulation, its delayed appearance, and flickering, fluctuating character suggest that the major feature is a weak pain, akin to prick, to 'pins and needles', to the sensations resulting from the application of a mustard plaster, or a weak interrupted current to the skin; of salt, pepper or ginger to the tongue.

For the direct comparison of heat and cold pain one finger was dipped into water heated to 65 or 75° C, another into ice water or the surface chilled by spraying with ether. Under these conditions heat and cold pain were found to differ, though hardly qualitatively. The former is more superficial, sharp, piercing, unsteady, throbbing out particularly strong just after the finger is removed from the water, and dying away into tingling, or soreness. The latter appears less abruptly, is deep, steady, massive, and spreading, especially to joints—wrist, elbow and shoulder—where it persists as a dull ache or strain sensation some time after the removal of the stimulus.

Our experiments were of course too roughly carried out to indicate whether the pain in either case represented overstimulation of temperature spots (Bader, Wundt), direct action upon pain fibres proper (possibly at different depths for heat and cold pain respectively) or a secondary effect related to vaso-motor changes. In favor of the first hypothesis stands the fact that pain adaptation seems to follow temperature adaptations, *i. e.*, a cooled finger responds painfully to lower temperatures than it would under ordinary conditions. In favor of the second, especially in so far as it concerns the

origin of heat pain in superficial, cold pain in deeper strata of pain fibres, stand the difference in depth of reference of the corresponding sensations, the customary sharpness of heat pain, the aching character of cold, and the frequent adapting out of the former, characteristics which tend to identify it with the superficial pain sensitivity to mechanical stimuli. Whether, however, the painful temperatures lie within the thermal limits of direct excitability of nerve fibres is a point which is apparently yet to be determined.

Experimentation with the swallowing of hot and cold water (55°C and ice water) revealed again the ambiguity of the term heat. The observer was at first inclined to locate a heat sensation (two or three seconds after swallowing) at the lower end of the œsophagus. After further study and observation of external temperature sensations, however, he usually reported merely a glow of warmth, appearing late and due probably to diffusion to the skin, or a certain momentary, radiating sensation, internally referred (at about the level of the stomach), bright and hardly distinguishable in the two cases of warm and cold stimulus, sometimes described merely as 'contact', sometimes as similar to his cutaneous experience of 'heat' or weak heat-pain.¹ This sensation was usually absent on repetition and may of course have represented a peritoneal or diaphragm, rather than an alimentary mucosa response.

For the comparison of different kinds of pain—itch, smart, burn, ache, etc.—the application of a mustard plaster to a small area on the arm, a sharp rap on the palm of the hand with a ruler, and heat and cold stimulation were employed. Typical introspections for the first refer to itching as made up of intermittent pain sensations, fusing now into a sharp sting referred to a single point on the skin,² now spreading and irregular as if hundreds of little bubbles were breaking through to the surface; followed by a suffused warmth coming in waves along with pain of increasing intensity until a fairly unanalyzable mass of heat and pain results. For the second: "Smart made up of prickly points; gets more steady, a general ache or throb; ache is below surface, large, of one piece, rounder edges than smart." Similar observations on heat and cold pain, and the use of ginger, pepper, vinegar, lemon, etc., on the tongue, bring out the fact that the observers feel no need of different

¹ It seems to us highly probable that in the infinitely more pains-taking experiments of Becher (*loc. cit.*), the 'temperature' sensations ascribed to the œsophagus were really of the nature of the sensations described above, due to the direct effect of comparatively high and low temperatures respectively upon internal fibres.

² This punctiform reference was not tested, but judging from other observations probably signifies only that pain was steady and sharp, not intermittent or dull.

qualitative terms in distinguishing any of these sensation experiences, even when for the sake of more exact comparison they followed closely in succession. Temporal qualifications, such as are implied in the terms intermittent, pricking, tingling, or intensive and spatial differences, seemed still to afford sufficient distinction. It is, however, to be noted that in connection with stimuli affecting either the mucosa, epidermis, or salivary glands the isolated sensation described as 'prick' or 'sharp' caused the observer some hesitation. While it is in itself neither painful, nor yet apparently possessing anything in common with the dull, massive quality usually identified with pressure, it stands in a sense between pain and pressure, since when intensified it passes gradually and insensibly into pain, and since also when an area of pricking sensations is allowed to die gradually away it merges into a massive dull sensation not dissimilar to pressure.

To sum up, we were left in considerable doubt as to the respective limits of the terms pain and pressure, the proper ranking of the pricking sensations, and their probable origin, whether in the skin or subcutaneous strata (in specific circulatory endings), in contractile or other changes in the walls of the smaller blood vessels. Further, we had so far failed to decipher any fixed qualitative variety among the pains of external origin which might serve as a guide or a clue in the analysis of internal pain. Lastly, a parallel series of casual introspections on visceral complexes indicated strongly that a thorough study of the external qualities and their different guises under the influence of intensive changes and reduplication, especially some investigation of the qualitative validity of the terms 'sharp' and 'dull' (which so far seemed to cover the most salient and distinguishing features of internally referred sensation), was a necessary preliminary to the successful analysis and description of the latter.

Significance of the terms 'sharp' and 'dull'; qualitative distinctions among cutaneous, subcutaneous and kinaesthetic sensations. A thorough study of certain variations of cutaneous qualities was accordingly undertaken, the results of which have already appeared in these pages, and may be summarized as follows. The typical simple cutaneous pressure (better *contact*) sensation, obtainable with moderate isolated stimulation of either pressure bulbs or 'pain' spots, is sharp or 'bright' in quality, and closely akin to the 'prick' which we had heretofore associated with stimulation by electric current and various irritants.¹ The granular pressure of Goldscheider is a

¹ XIX, 1908, 289 ff. A Qualitative Analysis of Tickling: Its Relation to Cutaneous and Organic Sensation.

complex, not a simple sensation, though qualitatively homogeneous. The ordinary dull pressure referred usually to lower strata, subcutaneous or muscular, appears under certain conditions of purely superficial stimulation of moderate intensity, as in the dying away of tickle. Tickle itself is not a peculiar organic quality, but represents a semi-analyzable pressure or contact complex and may be obtained directly from the isolated stimulation of a pressure bulb. The general bodily reaction conditioned by its irregular, flickering character, and strong dynamogenic power as an incompletely analyzed semi-cohesion of sensation probably accounts for the tendency to relate it to the organic or internal. Lastly, the dull pressure and the sharp prick above noted seemed with increase of intensity to pass into pain—dull ache in the former case, sting or sharp pain in the latter; the difference being probably a difference in massing and intensity merely. In a word, the results pointed to the possibility of reducing all the apparent multiplicity of sensation above cited, sharp and dull, to an astonishing qualitative simplicity.

Certain supplementary introspections combined with these experimental results, led to the formulation (in the above mentioned article) of the hypothesis that the whole muscle-skin continuum (barring pain, for the present) is qualitatively simple, and that its great apparent diversity is entirely explicable as a matter of 'form-color', or the peculiar temporal, spatial and intensive massing of similar sensations and the various resulting degrees of fusion, blurring, or flickering of the component parts.

In these introspections, of which unfortunately no considerable number was obtainable except from the writer, description was based as far as possible upon comparison with other more familiar or more easily designated sensations. The following descriptive summaries represent each from ten to twenty introspective studies made at odd moments for a period of about two years.

Gooseflesh. Arising from cutaneous stimulation—cold, the friction of clothing, nausea, rasping noises, and certain musical clangs. First, an apparently wave-like migratory sweep of sensation (after many repetitions analyzable into a multitude of vibratory or intermittent points), described at different times as pricking, seething, 'corkscrew', 'whirring', bright, glowing, shadowy, 'shivery', or flickering, localized just under the skin, likened to a feeble faradization of the skin, to pins and needles, or to a light breeze over the hairs; later losing their sharpness and merging often into a drawn, tense feeling. Temperature sensations rare or feeble. After repeated analysis it seemed probable that the 'migratory' character at first noted was merely a matter of intermittence; careful introspection revealed no onward sweep of the sensation, though successive patches might appear. The curious, uncanny feeling-tone usually present seems to arise largely from the somewhat ghostly suggestion of movement in the absence of any visualizable stimulus. A similar complex of sensations, but much fainter, hardly sharp at all, fine, shadowy, arises

when a current of steam or compressed air is allowed to strike the face: presumably from the same cause, the movement of the fine hairs.

Pins and needles; numbness; circulatory sensations. The first (from falling asleep of the arm) consists, as in the case of faradization of the skin, of tingling or pricking sensations, sometimes so rapid as to merge into a mere whir or even a dull, pressure-like sensation, usually described as 'numb'; when sharper, frequently shading into a muscle ache, or a feeling of iron tension, which seems to split up again into sharp, needle-like sensations, if the limb is moved or the muscles contracted. The application of turpentine to the skin gives rise at first to something very like a low-toned ache, but giving away rapidly to boiling, seething sensations which seem to get faster and sharper, but never painful so long as attended to; or to a decided pulling sensation (or tautness) as in gooseflesh, which, however, always vanishes with analytic attention, hence apparently represents an interpretation of a certain degree of fusion and not a peculiar quality to be ascribed to the plain muscle fibres of the skin, as some have supposed. The sensations attending excitation of the salivary glands through certain odors or tastes show the same peculiarities,—lively, vibratory sensations grading into 'strain'.

Muscle, strain and joint sensations. The former we found very difficult to identify under experimental conditions (anæsthetization of skin and galvanization of muscles). What we obtained was either a continuous dull ache, outlasting stimulation (very possibly related to the use of the ether on the skin), or a shooting, jerking, quivering line of sharp sensation associated apparently with the contraction of a smaller muscle. We, therefore, began to look among casual instances of sensations referred (rightly or wrongly) to muscle regions—to fatigue, drowsiness, relaxation, numbness, the shock of fright, of sudden waking, etc.,—for a clue to the peculiar quality usually ascribed to muscle sensations by experimentalists.

It was first necessary to throw out the strain sensations, which we found readily identifiable, easily excited by voluntary muscle contraction, and accurately localizable, either directly or by pinching. They grade imperceptibly into pain, and are easily matched by pressing firmly over any bone or muscle. The remainder of the sensations referred to the deeper strata (apart from the pricking sensations already ascribed to pilomotor or circulatory changes) comprise a certain dull, massive, ill-defined 'tridimensional' feeling indistinguishable from pressure and present sometimes as a sense of the hugeness of the limbs in fatigue, in drowsiness or after a heavy sleep (when the peripheral capillaries are dilated). This sensation, the voluminousness of which is perhaps a suggestion from its mere aggregate character as representative of the stimulation of innumerable endings, may be in part cutaneous, but is present characteristically with prolonged massage, long after the superficial contact sensations have adapted out. It seems sometimes to be peculiarly unsteady (though this may be merely the effect of a shifting attention), and grades imperceptibly into a dull ache.

Certain other sensations are referred to the muscles, though possibly arising from circulatory changes, contraction of sweat duct fibres, etc. These are bright rather than dull, and arise *en masse* when we receive a sudden physical or mental shock—are angry, hurt, moved to pity, suddenly awakened from a nightmare, and the like. They are frequently sharp, 'corkscrewy', and fade quickly; the feeling as if 'boiled to shreds' described by James is apparently identical.

While it is, of course, probable that many of the sensations above described may originate in peculiar nerve-endings—muscle, tendon,

plain muscle, circulatory and the like—as it is certain that many of them originate in changes in the above-mentioned tissues, there is little warrant for assigning peculiar, individual qualities to such endings, since most of the characteristics of muscle, joint, skin, or tendon sensations may, under appropriate conditions, appear in the other tissues.

Varieties of Pain: dumpf and stechend, stabbing and cutting. With regard to this two-fold division, which is apparently accepted as ultimate and referred to different sensory systems (deep and superficial) by Nagel, Thunberg, Ebbinghaus, and probably Head, one or two points may be added. Pricking pain sensations may die away into a diffuse ache. A characteristic ache (deep, massive, and more or less dull) may, through changes in intensity or attention, swell out into a 'bright', almost sharp pain and die away again without otherwise altering in character, as embers may glow and dull again. It seems reasonable, therefore, to assume that here also the basis of division is merely a matter of spatial and intensive massing. Superficial nerve endings are, of course, more exposed to isolated and violent stimulation; deeper lying ones to massive and distributed attack.

PAIN: THE CONCEPT OF INDIFFERENT PAIN

Experimental. The immediate purpose here was to examine the nature of liminal and full-fledged pain sensations, their relation to the pressure (or contact) sense and its endings, and to determine whether this relation rises gradually along a graded series of stimulus intensities or springs suddenly out from painless sensation, as many assert. The results of these experiments, which were comparatively few and limited to the testing of pain spots with mechanical thermal and electric stimuli, have been already outlined in the article quoted. Two important facts disclosed were the existence of a graduated series of sensations ranging from vague indifferent punctiform pricks to pain (along a scale of graded stimulus intensities), and the uncertainty or instability of the pain judgment. Whether the same would hold for all pain endings or all stimulus forms we can hardly conjecture. With a fine pointed stimulus (needle) and a light momentary touch the response of a pain spot is frequently a tiny, *itchy*, irregular, apparently irradiating and delayed sensation, as under similar conditions the characteristic response of a pressure organ is tickle. In general, secondary or delayed pain (which at first we thought might represent the effect of vaso-motor reflexes in deeper endings) was obtainable from any pain spot if lightly enough stimulated; these delayed sensations are, however, strictly speaking, not always painful. Lastly, with intenser stimulation pain was obtainable from any pressure bulb tested.

Introspections and conclusions. Observations on the stinging or prickling sensations felt in the skin with light twisting massage, in the nostrils just preceding a sneeze, in pins and needles, and many other cases already quoted have revealed

sensations closely akin to the sensory aspect of pain, and yet unpainful, indifferent or even pleasant. Hence our inclination, already admitted, to credit the pain sense proper with a stretch of indifferent sensations in the direction of its lower limen, to regard the 'pain' quality as not alien to the pressure-contact-muscle-strain continuum, but simply representative of its upper stretches. It will, of course, be objected that in ordinary pain (*e. g.*, a needle prick) there is something peculiarly penetrating, peculiarly explosive, vivid, or stinging. Careful introspection, however, seems to resolve these peculiarities into a matter of abruptness of outswelling, of intermittence and apparent irradiation (in the case of itch), of complexity (in the case of tearing, wrenching pain), or into a matter of attentive vividness and general bodily reaction.

In cases of pricking or piercing sensations which seem to lie upon the border line, the observer, when doubtful, customarily basis his judgment upon his rebelliousness against the sensation. If now the natural reflex revulsion can be inhibited, or the sensory core singled out and dispassionately regarded by the attention, it temporarily loses its painful character and becomes merely an exceedingly vivid, live, sharply defined sense perception. Further, many sensations which, if momentary only are hardly painful, become so if continued, even when the sensation itself, if carefully noted, is neither intensified (by summation) nor otherwise altered. Neither is this a matter of an added diffuse unpleasantness, but rather of a complex dynamogenic effect. When the assault of any pain sensation which, if come upon unawares, would automatically grapple the attention and excite the impulse of avoidance or escape, is, as it were, headed off, the reaction inhibited, or some other substituted (as is possible only momentarily or not at all if the sensation is of considerable violence), the unbearableness, and with it the painfulness is lost.

It therefore seems to us that the pain consciousness represents neither a simple feeling or sensation,¹ nor a peculiar sense quality plus a simple and invariable unpleasant affective element, nor yet merely a peculiar sensation plus sometimes indifference, sometimes unpleasantness, but rather a peculiar miscellany or complex, an assimilation or welding of the immediate sense content (brilliantly illumined by attention) with a great bodily and mental reaction, the shorthand expression for which is 'intolerability'.

In taking this position we have, as above indicated, no intention of reverting to the earlier and cruder interpretation which,

¹The *Gemeingefühlsempfindung* of the physiologists of the early nineteenth century; the *Gefühlsempfindung* of Stumpf.

confusing painfulness and disagreeableness, identified the pain consciousness as a peculiar 'feeling' and lightly posited the transmutation into pain of any specific sense quality or any specific nerve excitation—visual, auditory, temperature, or tactual. A concrete, specifically localizable aspect of pain is, we maintain, always present, and is sensory in the ordinary significance of the word.¹ Whether or not it is in many or all cases mediated by a specific end station and spinal pathway (*via* collateral connections in the cord), we are inclined to regard it as qualitatively alike in all senses and closely related to the indifferent prick.

In support of this concept of indifferent 'pain', certain theoretical considerations may be added. First, the facts of hyperalgesia and summation are hardly explicable upon the assumption of a high peripheral limen. Further, the concept enables us to account for the various sensations received from the viscera and inner tissues (painful, indifferent and pleasant) without a needless or difficultly intelligible duplication of nerve apparatus.

Summary. The net results of the above experimentation, so far as it bears upon the problems of organic sensation, may be summarized as follows :

1. The differentiation of external and internal sensation is less obvious, and the conditions of external or internal reference more complex than we at the outset imagined. A large number of internally referred sensations quite probably arise from the excitation of cutaneous nerves.
2. The texture or massing of sensation is as important in creating apparent qualitative differences (sharp and dull) as is the original sensory element itself.
3. Internal sensations may differ from external texturally rather than qualitatively, just as tickle differs from pressure merely from being so put together that it constitutes a 'feeling' rather than a sensation compact, is affectively vivid while perceptually vague.
4. The possibility of an indifferent beginning of the pain continuum offers a valuable suggestion for the solution of some of the problems of internal sensation.

¹That is, we assume that intense visual or auditory stimuli can evoke the pain reaction only when attended by veritable 'pain' sensations, by whatever mechanism aroused.